Issued November 24, 1916.

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF SOILS—MILTON WHITNEY, Chief.

IN COOPERATION WITH THE NORTH DAKOTA AGRICULTURAL EXPERIMENT STATION, THOMAS P. COOPER, DIRECTOR.

SOIL SURVEY OF DICKEY COUNTY, NORTH DAKOTA.

BY

T. M. BUSHNELL, IN CHARGE, E. H. SMIES, AND W. I. WATKINS, OF THE U. S. DEPARTMENT OF AGRICULTURE, AND A. C. ANDERSON, MELVIN THOMAS, MURRAY E. STEBBINS, R. C. DONEGHUE, AND J. W. INCE, OF THE NORTH DAKOTA AGRICULTURAL EXPERIMENT STATION.

CURTIS F. MARBUT, INSPECTOR IN CHARGE.

[Advance Sheets—Field Operations of the Bureau of Soils, 1914.]

WASHINGTON:
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1916.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS,
Washington, D. C., March 20, 1916.

SIR: In the extension of the soil survey in the State of North Dakota work was undertaken in Dickey County and completed during the field season of 1914. This survey was carried on in cooperation with the North Dakota Agricultural Experiment Station, and the selection of the area was made after conference with State officials.

I have the honor to transmit herewith the manuscript report and map covering this work and to recommend their publication as advance sheets of Field Operations of the Bureau of Soils for 1914, as provided by law.

Respectfully,

MILTON WHITNEY,
Chief of Bureau.

Hon. D. F. HOUSTON,
Secretary of Agriculture.

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SOIL SURVEY OF DICKEY COUNTY NORTH DAKOTA.

By T. M. BUSHNELL, In Charge, E. H. SMIES and W. L. WATKINS, of the U. S. Department of Agriculture, and A. C. ANDERSON, MELVIN THOMAS, MURRAY E. STEBBINS, R. C. DONEGHUE, and J. W. INCE, of the North Dakota Agricultural Experiment Station.

DESCRIPTION OF THE AREA.

Dickey County, N. Dak., lies on the eastern part of the southern boundary of the State. It is rectangular in shape, and is bounded on the north mainly by Lamoure County, on the east by Sargent County, on the south by the South Dakota State line, and on the west by McIntosh County. The county is 48 miles long and 24 miles wide, and has an area of 1,142 square miles, or 730,880 acres.

Dickey County occupies portions of two plains, known, respectively, as the Prairie Plains and the Missouri Plateau. The first of these is the lower, having a range in elevation from about 1,300 to 1,600 feet above sea level. Although there is a gradual descent from the west, the area slopes also toward the south, as is indicated by the stream courses. The greater part of the surface is characterized by an undulating to gently rolling topography.

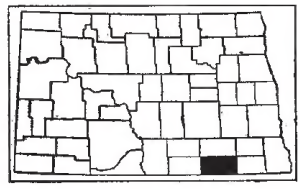


FIG. 1.—Sketch map showing location of the Dickey County area, North Dakota.

The local topography is uniform over the country, being typically that of a ground moraine of faint expression, with extremely faint dissection. The valleys, excepting that of the James River, are rarely more than 25 feet deep or one-fourth mile in width. The James River has a valley about 125 feet deep and varying in width from about 1 mile to more than 8 miles in the expansion of the valley south of Oakes, known as the bed of Lake Dakota. The latter is a broad plain of constructional water-laid topography lying about 20 feet above the level of the James River. (See Pl. I, fig. 1.)

Beginning on the southwestern side of the big bend of the James River and following a course slightly west of south is what appears to be the remains of an old spillway of the James River. This is about 3 miles wide at the north end, but narrows after passing a point just west of Clement. It practically disappears in Kent Township, but there are indications that the drainage divided at this point, one branch going south just west of Guelph and the other passing

east of Silverleaf on its course toward the Maple River Valley. This strip of land is characterized by a large number of poorly drained areas, which occur in chains, and by rough topography in contrast with the surrounding country.

The second main physiographic division of the county, the Missouri Plateau, is a plain like the Prairie Plains, but it has an elevation of about 2,000 feet above sea level. In this region there are two types of minor surface relief; one consists of the comparatively narrow, eroded edge of the plateau and the other of the surface of the plateau covered by sharply rolling morainic hills with small inclosed basins of restricted drainage. This plateau is known as the Missouri Coteaus, and probably represents a preglacial plateau modified by the deposition of glacial material on its surface. The overburden of glacial drift is a part of the Altamont moraine. The eastern bounding escarpment passes across the State in a northwest-southeast direction, but in this county its front has a north-south direction. Its width in the county varies from about 9 miles in the northern part to about 6 miles in the southern part. At the northern line of the county the ascent from the lower plain is gradual, but toward the south the slope is much steeper and the ascent of 200 feet or more takes place in less than a mile. On the plateau proper regional drainage has not been established and the original constructional surface has been little modified by erosion.

The regional drainage of the county, where it has been established, is effected by a large number of almost parallel streams which have a general trend slightly east of south. The larger streams, the James and Maple Rivers, make their eastward turn through sharp bends in the northern part of the county. The main drainage ways that rise in the county follow a course almost due south to the county line. The James River is the most important stream in the county, and all the streams after they leave the county find their way, through the James, into the Missouri.

In the old Lake Dakota basin local drainage has not been established, but the rainfall sinks rapidly into the sandy soil. In low areas of heavy soil where seepage accumulates poorly drained areas, lakes, and marshes occur. Local drainage is poorly established along the eastern edge of the upland prairie. Toward the moraine, as the slope is more pronounced, drainage ways are more generally developed, but there are still many extensive areas without streams. In most places the run-off is carried into depressions by shallow swales. Innumerable small areas of restricted drainage are found over the entire region, except on the slopes bordering the moraine.

The population consists mainly of immigrants and the descendants of immigrants who came into the county principally from Wisconsin, Iowa, Illinois, and other Central States. According to the 1910 census, 77.6 per cent of the population is native born. The

greater part of the foreign-born population is from Russia, Norway, Canada, and Finland. The total population of the county is reported in the census of 1910 as 9,839, as compared with a total of 6,061 reported in 1900. The entire population, as reported in 1910, is given as rural, and averages 8.6 per square mile.

The two principal towns in Dickey County are Ellendale, which is the county seat and has a population of about 1,400, and Oakes, with a population of about 1,500, according to the 1910 census. These are progressive cities with modern improvements. Fullerton, Forbes, Monango, Ludden, Merricourt, and Guelph are small towns with populations ranging from about 100 to 300.

Dickey County includes somewhat over 130 miles of railroad and 20 shipping points. One-half the farms of the county are within 3 miles of some elevator or loading platform and four-fifths within 6 miles. A large area in the vicinity of Wirch is 10 to 18 miles distant from the nearest railroad. The railroads afford direct transportation to Minneapolis and St. Paul, and the markets in these cities determine the values of farm products in Dickey County to a large extent.

A strip along every section line is legally reserved for a public road, but the roads are interrupted in a few places by natural obstacles, especially along the James and Maple Rivers and in the rough country in the western part of the county. Most of the roads are mere wagon tracks worn down through the prairie sod to depths of 4 to 12 inches, but the main roads to the towns usually are graded. Much interest is being taken in the establishment of good roads, and the old trails are being fenced across, while scrapers and grading machines are being used for building fills through depressions and digging road ditches. Where available, gravel is used as a surfacing material. The James River is bridged at seven well-distributed points in Dickey County, while the roads on twenty or more section lines stop near its banks.

Two sections in each township are reserved for school purposes, and the country schools are in good condition and well conducted for a new, thinly settled country. Telephone lines and the rural delivery of mail reach all parts of the county.

CLIMATE.

The climate of Dickey County is subhumid, with comparatively long winters and short summers. Thawing weather usually begins about the middle of March, and field work starts by April 10. From this time until May 10 the weather is usually quite cool and growth is comparatively slow. After this time the higher temperature and long bright days result in a much more rapid growth, which continues until the small grains mature, except when growth is checked by occasional periods of drought. There are very few hot days and the nights are cool.

As a rule, the fall season is comparatively dry and there are many days of fair weather. The ground seldom freezes before the middle of November. During short periods of extremely cold weather the thermometer may occasionally register as low as 40° below zero. The dry air makes the cold less penetrating than in the more humid regions. These periods are less disagreeable than when "blizzards" occur, and moderately low temperatures are attended by high winds.

Weather Bureau observations at Berlin for 19 years show the frost-free period to be 102 days. The average date of the last killing frost in the spring has been June 2, and the first in the fall September 12. The latest frost in the spring has been June 21, and the earliest in the fall August 31. At the substation at Edgeley 15 years' records, 1901–1914, show the frost-free period to be 129 days. The average date of the last killing frost in spring is May 14 and the first in fall September 20. At Fullerton, Weather Bureau records show the frost-free period to be 122 days, the average date of the last spring frost being May 17 and the first fall frost September 16. The latest in the spring occurred on June 7 and the earliest in the fall on August 12. The average frost-free period for the three points is 117 days.

Normal monthly, seasonal, and annual temperature and precipitation at Fullerton.

Month.	Temperature.			Precipitation.		
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year.	Total amount for the wettest year.
	°F.	°F.	°F.	*Inches.*	*Inches.*	*Inches.*
December	14.3	53	−33	0.95	0.45	1.89
January	10.4	60	−40	0.63	0.02	1.17
February	9.0	58	−38	0.66	0.40	0.22
Winter	11.2	60	−40	2.24	0.87	3.28
March	24.0	72	−27	1.57	0.67	0.89
April	42.1	88	−15	1.88	1.35	2.82
May	53.2	95	13	3.36	2.24	8.08
Spring	39.8	95	−27	6.81	4.26	11.79
June	62.3	100	26	3.23	1.56	4.43
July	67.6	105	32	3.13	2.68	5.39
August	66.3	102	31	2.92	2.45	2.20
Summer	65.4	105	26	9.28	6.69	12.02
September	56.5	99	16	2.07	0.64	2.89
October	44.4	86	10	1.52	1.74	1.63
November	29.3	72	−27	0.72	0.18	2.26
Fall	43.4	99	−27	4.31	2.56	6.78
Year	40.5	105	−40	22.64	14.38	33.57

Records of the rainfall during the seven months from April to October are available for the five-year period 1910–1914. These are given in the following table:

Summary of rainfall data at Oakes Demonstration Farm.[1]

Month.	1910	1911	1912	1913	1914
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*
April	0.00	0.98	2.72	0.79	3.62
May	.56	4.12	3.91	2.40	1.15
June	1.56	2.18	2.17	2.32	6.97
July	.94	1.56	5.73	2.80	3.07
August	2.28	2.78	2.68	3.14	.76
September	3.28	2.94	2.48	.84	1.75
October	.40	.85	.12	3.56	.64
Total	9.02	15.41	19.81	15.85	17.96

[1] Compiled from published records in Annual Reports of the Superintendent of Demonstration Farms 1910–1914.

A record of evaporation from a free water surface during the growing season have been kept for several years at the Edgeley substation. This together with precipitation for the same period is summarized in the following table:

Precipitation and evaporation for the growing season, 1907–1912.[1]

MONTHLY PRECIPITATION.

Month.	1907	1908	1909	1910	1911	1912
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
May	1.89	3.55	4.01	0.36	2.31	3.25
June	1.73	3.26	2.60	1.57	1.19	3.82
July	2.77	1.19	3.04	.60	1.76	5.70
Total	6.39	8.00	9.65	2.53	5.26	12.77

MONTHLY EVAPORATION.

May	3.41	4.08	4.40	5.68	5.47	4.40
June	5.46	5.21	4.19	6.72	5.43	3.06
July	5.98	7.04	5.63	8.19	7.56	5.70
Total	14.85	16.33	14.22	20.59	18.46	13.16
Evaporation times rainfall	2.32	2.04	1.44	8.14	3.51	1.03

[1] N. D. Agr. Expt. Sta., Tenth Annual Report of the Edgeley Substation 1912, p. 11.

Seven years' records during the months of April to September show the average total evaporation from a free water surface to be equivalent to 30.42 inches of rainfall.[1]

[1] N. D. Agr. Expt. Sta. Bul. 110, p. 169.

Over one-half the rainfall comes in May, June, July, and August. This is fairly well distributed through these months. On the better soils that are well tilled and in a high state of fertility the average rainfall during these months alone is sufficient to produce a fair crop, if it could all be utilized. The evaporation from a free-water surface is quite high and indicates that moisture can be lost very rapidly from a moist soil.

AGRICULTURE.

The lands of the county were surveyed and opened for entry in the early eighties, and considerable land was taken up in the eastern part of the county by homesteading, preemption, and tree claims. In 1890 the census figures show that 337,844 acres, or about 45 per cent of the county, was in farms. Of this, 178,460 acres, or about 53 per cent of the land in farms, was improved. In 1900 there were 470,910 acres in farms in the county, or 63 per cent of the land area. The percentage of improved land in farms was practically the same as in 1890. In 1910 there was 594,630 acres, or about 80 per cent of the land area, in farms, and about 69 per cent of the land in farms was improved.

The average value of land in farms advanced from $5.40 to $33.45 per acre in the decade from 1900 to 1910. During this decade the value of farm buildings advanced from 94 cents to $3.06 per acre of land in farms, the investment in farm machinery from 45 cents to $1.66 per acre, and the investment in live stock from $2.07 to $3.86 per acre.

While there has been a great increase in the land area in farms during the 20-year period from 1890 to 1910, the number of farms has not shown a marked increase. In 1890 there were 997 farms in the county, and the average size was 339 acres. In 1900 the number had decreased to 933 and the average size had increased to 504 acres. In 1910 there were 1,089 farms, the average size being 546 acres. Of this number 792 were operated by owners. These 792 farms constituted 73 per cent of the land in farms and averaged 610 acres per farm. Seventy-eight per cent of the land in farms was improved. This is 9 per cent more than the average for the country. The greater part of the land not operated by owners is leased under the share-tenant system.

Wheat has always been the principal crop grown in Dickey County, although there has been a gradual decrease in the percentage of improved land in farms that has been seeded to this crop. In 1890 the wheat acreage was 52 per cent of the improved land in farms, while in 1900 it was but 41 per cent and in 1910 it was 38 per cent. Oats have been grown primarily for horse feed, and the relative acreage has not changed materially. Barley supplemented wheat as a sale

crop to some extent on some farms, as is shown by the fact that the percentage of the improved land in farms devoted to this crop increased 7 per cent during the decade from 1900 to 1910. While barley has taken the place of wheat to some extent on old land, flax has supplanted it to a considerable extent on newly broken prairie sod. The percentage of the improved land devoted to flax increased approximately 5 per cent during the 20-year period from 1890 to 1910. This increase was no doubt due to the breaking of new prairie sod, because flax is usually grown when the sod is broken up. Flax is not very generally grown on land that has been under cultivation for any length of time.

In 1899 there were 52,384 acres of wild hay cut in the county, and in 1909 there were 58,212 acres. Prior to the time the land was put under cultivation it was used for ranching, and considerable wild hay was cut for feeding the live stock during the winter. The census figures show that only 125 acres were devoted to the production of forage crops in 1900, but in 1910 there were 3,327 acres of tame and cultivated grasses. Most of this was timothy and millet.

Rye and broom-corn millet are grown to some extent in the county, and potatoes and other vegetables are grown for home use.

The census figures show that there were 3,170 plum trees in the county in 1909. Some strawberries, raspberries, currants, and gooseberries are also grown.

Before the land was brought under cultivation considerable live stock was grazed in the county under the ranching system. The cultivation of the land broke up the ranches, and much of the live stock was sold. Many of the farmers are beginning to stock their farms, so that eventually there will be considerable live stock raised in the county. The changes that have taken place in the live-stock industry are illustrated in the following table:

Number of acres in farms for each head of live stock, 1890–1910.

Animal.	1890	1900	1910
	Acres.	*Acres.*	*Acres.*
Horses	72	61	47
Milch cows	116	116	114
Other cattle	50	26	50
Sheep	75	23	435
Hogs	110	117	62

The ratio of horses to land in farms has steadily increased during the 20-year period. This is probably due to the fact that a greater proportion of the horses are now used on the farms and fewer on ranches, where they were formerly used as saddle horses. The ratio

between milch cows and the land in farms has not changed, showing that during this period the dairy products were largely consumed on the farms. The ratio of other cattle has undergone some marked changes. There were over twice as many acres of land in farms per head in 1890 as in 1900. Probably most of the cattle were on ranches which were not included in the land in farms, so that this would not necessarily represent an increase in the number of cattle on the farms. This is borne out by the fact that there were only one-half as many acres of land in farms for each head in 1900 as in 1910, while there was an increase in the acreage under cultivation. The same conditions apply to sheep, except that the differences were more marked, showing that the sheep sold from the ranches have not been replaced as generally as has been the case with cattle. The number of acres in farms for each hog did not change materially during the first decade, but there was a decrease of 55 acres per hog from 1900 to 1910. Hog raising is becoming more general and some of the corn grown is hogged off in the fall. Beef cattle are raised on some of the farms in the county. They consume much of the roughage that would otherwise be unmarketable, and where they have access to straw stacks they convert large amounts of straw into manure so that it can be returned to the soil to build up the organic content.

The agriculture of the region is still comparatively new, and little attention has been given to the adaptation of crops to soils. The same crops have been grown on all types. The problem of checking the drifting of certain soil types by the wind has led some farmers to grow crops that make it possible to utilize these soils to better advantage. The necessity of ridding wheat land of weeds has also caused some diversification of crops. While some of the land has been cultivated about 30 years, there is much of it that has been under cultivation a much shorter time. Although the live-stock industry has undergone some changes, this has not been due to change in the method of farming, but rather to a change from ranching to farming. Small grains have been grown almost exclusively until the last few years. Much of the land has become infested with wild oats and some other weeds under this system. The acreage of corn has increased quite rapidly and quite a number of farmers are planting large acreages. Good yields are obtained and the crop is proving to be one of the most profitable in the county. Many farmers are growing alfalfa in a small way, and it is one of the most promising hay crops. Considerable broom-corn millet is grown for seed.

VARIETIES OF GRAIN.

Variety trials at Edgeley, in Lamoure County, during an 11-year period show that the durum wheats yielded from three to five bushels

more than the Fife or Blue-stem varieties. Velvet Chaff or bearded spring wheats have not yielded quite as much as the Fifes and Blue-stems, and Ghirka spring wheat has produced about the same yield as these varieties.

The early oats, such as the Sixty Day and Kherson, yield more in dry years than the medium and late ripening strains. The late oats, for example the White Russian, are more rust resistant than early or medium maturing strains. The medium-maturing varieties, such as the Siberian White, outrank the other sorts in point of yield, for an average during a term of years. The Kherson and Sixty Day oats yielded from 20 to 25 bushels per acre in the dry season of 1910 and 1911, where most of the other sorts were a failure. From the data accumulated, it would seem advisable for the farmers to sow about half their acreage intended for oats to one of the early strains and the balance to a medium-ripening sort. On an average the early oats ripen about 15 days before the other varieties are ready to harvest. As very hot, dry weather usually occurs after the middle of July, which is the ripening period of the early varieties, very little damage is done by drought.[1]

The 6-rowed barleys have yielded slightly more than the 2-rowed varieties.

The suitability of a variety of corn for the county depends largely upon the region in which the seed has been produced. Rustler White Dent and Minnesota No. 13 Yellow Dent can be grown quite successfully in the region, if seed from a strain that has been growing in the region for several years is planted. Early strains of these varieties have been produced by growers in this and adjoining counties who have been selecting for earliness for several years. The growing season for corn is too short for strains of these varieties grown in the States farther south. Mercer Flint grown from northern-grown seed makes a good silage corn. Early selected improved strains of Northwestern Dent are well suited to the region. Gehu Flint and Dakota White Flint can be grown successfully and are well suited to hogging off.

TILLAGE METHODS.

Experiments have been in progress for several years at the Edgeley substation to determine the best methods of seed-bed preparation. Though these results apply more particularly to the management of the Edgeley loam they have a general bearing on tillage practices of many of the soils of the county. The results also indicate the benefits of tillage practices in general, as compared with other phases of soil management.

Experiments have been in progress since 1909 to determine the effects of different times of plowing on the yield of wheat in a system of continuous cropping. The average yield has been slightly higher on spring-plowed than on fall-plowed land. Early-fall plow-

[1] N. D. Agr. Expt. Sta., Tenth Annual Report of Edgeley Substation, p. 30.

ing (about Sept. 1) is best. Under farm conditions early-fall plowing would probably prove more profitable than spring plowing, because when a considerable acreage of grain is seeded some of it must necessarily be seeded rather late, if the sowing is delayed by plowing in the spring. The decrease in the yield due to this later seeding would usually be enough to offset any better soil conditions that might be brought about by spring plowing. If the acreage devoted to grain is not too great it would probably be better to plow in the spring than late in the fall.

During this same period an investigation has been made to determine the relative yields on land plowed 5 inches deep and land plowed 8 inches deep. This work has been done on both fall and spring plowed land. The yield on fall-plowed land has been practically the same for both depths, while the difference in the spring has been within the limits of experimental error. These results show that there is little advantage in plowing over 5 or 6 inches deep in a system of continuous grain growing under the soil and climatic conditions of the region.

Plowing has a loosening effect on the soil, and on some of the coarser textured soils that are naturally loose in structure it is possible that deep and frequent plowing makes them too loose for the best growth of crops. This is borne out by results of an experiment, in which the land was cropped continuously to wheat as in the foregoing plowing experiments. One set of plots was plowed in the fall and seeded the following spring. No tillage was given in the fall after harvest, but the following spring the stubble was disked and seeded to wheat. On the other set of plots the ground was plowed for wheat in the spring and seeded. The stubble was disked that fall and seeded the following spring. In this way the land was plowed but once in two years.

As an average for the two systems of treatment, the yields were 1.55 bushels per acre higher in years in which the land was plowed, but the only treatment that produced a greater average yield when the land was plowed every year was the spring plowing, and this yielded only about one bushel more. While a system of alternate plowing and disking of this kind might not be advisable as a permanent system, because of the fact that continuous cropping to grain is becoming impractical, the data show that a cropping system devised so that plowing will not need to be done every year would result in better yields. In a region of relatively low rainfall the soil settles slowly and when stirred deep too frequently the best conditions for the movement of soil moisture and the growth of crop roots do not exist. The cultivation of corn grown in the rotation packs the soil and produces a soil structure that, while loose enough to favor bac-

terial activities, is uniform and compact enough to permit the movement of soil moisture and plant food for crop nourishment.

In order to overcome the loosening effect of deep and frequent plowing in the subhumid region it has been suggested that the soil be packed after plowing. In order to determine the effectiveness of subsurface packing an experiment was conducted in which 8-inch fall and spring plowing was packed. A comparison of the yields of these plots with plots similarly treated but not packed showed that packing was ineffective in bringing about a soil structure that is favorable for the growth of wheat. A more compact structure is needed, but the packer does not seem to compact the soil uniformly and thoroughly enough to improve its condition for the growth of wheat in a system of continuous cropping.

During the 4-year period, 1912–1915, subsoiling experiments have been in progress at the Edgeley substation. Hard wheat, durum wheat, barley, oats, and corn have been grown in these trials.

The land was subsoiled to a depth of 7 inches below the 6-inch plowing, thereby stirring the soil to a depth of 13 inches. The subsoiling and packing have been done but once during the 4-year period, for the 1912 crop, except where barley was grown, which was subsoiled and packed in 1913. All plots have been plowed 6 inches deep each year. There has been no appreciable increase in yield due to the subsoiling or packing for hard wheat or durum, except in 1912, when there was an increase of 4 bushels. This was offset by the lower yields in the subsoiled plot in 1913 and 1915, so that the operation would not be profitable.

The three years' work with barley shows a slight decrease for subsoiling, both when packed and when not packed. The subsoiling produced a slight increase in the yield of oats and corn as an average for the 4-year period, but packing reduced the yield below that of the 6-inch plowing in case of both crops. The value of the increased yield of oats on the subsoiled plots in 1912, less the decrease in the three succeeding years, was $2.34 per acre and that of the corn fodder $2.06, when oats are figured at the average farm price for the 10-year period 1905–1914 and corn fodder at two-thirds the average price of hay during this period.

During a period of nine years at Edgeley 12 plots of corn ground have been disked for wheat and 3 have been plowed. As an average of all these for the entire period the wheat on the plowed plots has yielded but one-tenth bushel per acre more than that on the disked plots. Oats on corn ground plowed yielded the same as on disked corn ground.[1]

[1] N. D. Agr Expt. Sta. Bul. 110, pp. 183, 194, 199.

SUMMER TILLAGE.

In comparing the yields of crops on land that grows a crop every year with those on land that is fallowed and tilled during the summer to keep down weeds, it is found that the summer-tilled land produced an average yield of 1.6 bushels per acre, or about 12 per cent, more wheat than land cropped continuously during a 9-year period of investigation. Oats yielded 15.7 bushels per acre, or 58 per cent more, and barley 3 bushels per acre, or 17 per cent, more, on summer-tilled land. The yield of corn was slightly lower on summer fallow than on land that grew corn every year.

The results of the foregoing experiments show that under these conditions the yield of small grain can not be materially increased by plowing deeper than 5 or 6 inches, by subsoiling or by packing in a system of continuous cropping. They further indicate that when land is plowed every year the soil is loosened too much, especially in the case of the coarse-textured soils under the climatic conditions of the region. This loosening can not be corrected by the use of the packer enough to make subsurface packing profitable on the Edgeley loam. When the packer is used the structure of the soil is not as uniformly compact as when it is allowed to settle for more than one year. The cultivation of corn works the soil into a uniformly compact structure gradually and at the same time eliminates weeds and leaves the soil in good physical condition for small grain, so that plowing is unnecessary for the succeeding crop of small grain. Two crops can be grown with one plowing in this way and the soil will be in good tilth for both. For most farm conditions early-fall plowing of grain stubble would prove best for growing a second crop of small grain. Small grain grown on spring plowing will yield better than on late-fall plowing, provided the grain can be seeded equally early in the spring.

The practice of summer tillage or the clean culture of bare fallow every other year has not been found profitable. It may be advisable to give the land summer tillage once in 4 or 5 years as a means of cleaning the land of weeds, but the growing of corn or potatoes in a rotation would prove more profitable.

The tillage methods that should be followed vary somewhat with the soil type. The purpose of tillage practices on all soil types is to eliminate weeds, to improve soil structure, to facilitate the absorption of the rainfall by the soil and the movement of the moisture in the soil, so that crops are supplied with food at critical stages in their growth, and to promote the action of soil bacteria. These effects are produced in different soils by different systems of soil management. A clay soil has a tendency to become refractory and offers considerable resistance to the growth of crop roots unless it

FIG. 1.—LAKE DAKOTA REGION, LOOKING WESTWARD FROM TOP OF A SAND DUNE.

Dune is just inside of Sargent County.

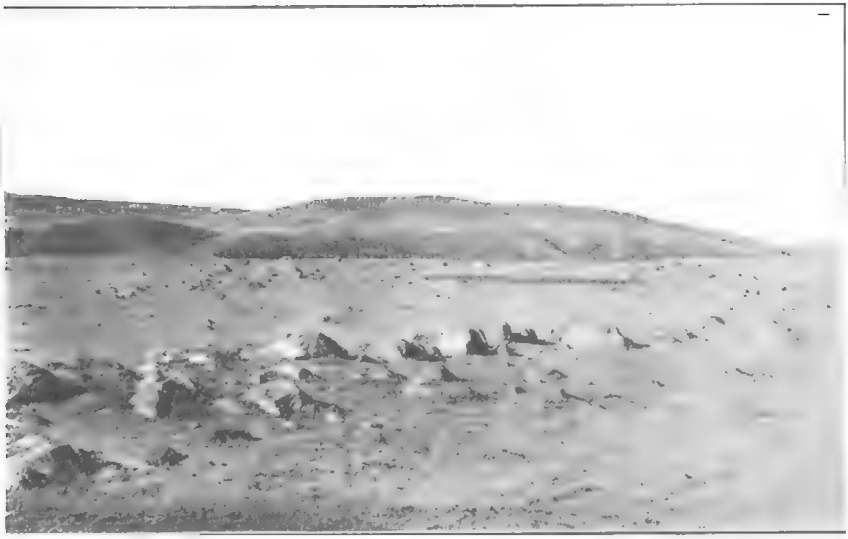


FIG. 2.—SIOUX GRAVELLY LOAM, COLLUVIAL PHASE, WITH ROUGH BROKEN LAND IN BACKGROUND.

A deep draw occurs between this flat and the hills.

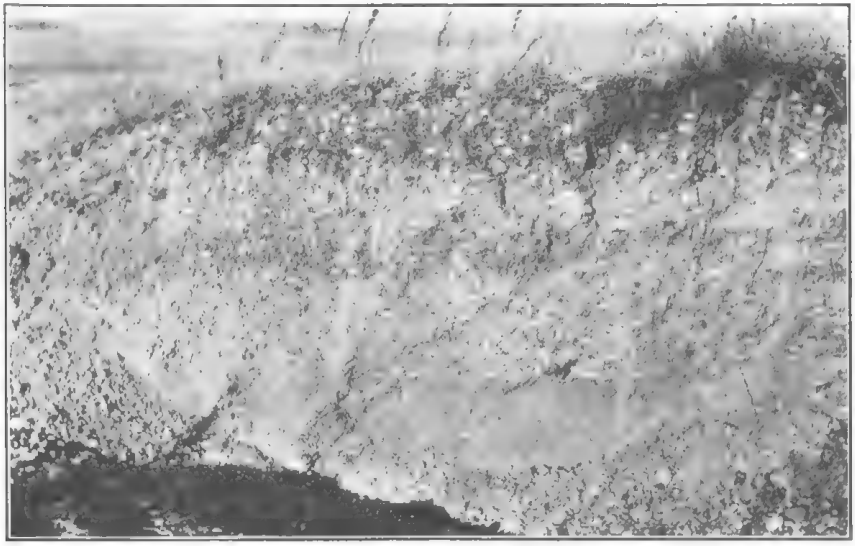


FIG. 1.—CUT IN WILLIAMS GRAVELLY LOAM.

Here there is some stratification, and the gravel occurs along the slope of a long morainal hill.

FIG. 2.—"GULCH" IN ROUGH BROKEN LAND NORTHWEST OF FORBES.

is worked into a granular condition. This is accomplished by plowing, disking, and harrowing when the soil contains the proper amount of moisture. Obviously, different systems of tillage should be followed in the management of a sandy soil, where the principal object of tillage, from the standpoint of modification of soil structure, is to incorporate organic matter and produce a uniformly compact structure, so that as much moisture as possible will be retained.

CROP ROTATION.

While proper tillage is important from the standpoint of economy in the production of a maximum crop, the best results can not be obtained unless crops are grown in a rotation.

During a period of eight years the yields of wheat at Edgeley have been practically the same on corn ground as on summer tillage, the yields of barley have been 3.4 bushels less on summer tillage, and the yields of oats have been 5.2 more on summer tillage than on corn ground.[1] The average value of the corn fodder produced during that period, calculated from the average yield of 22 plots at two-thirds of the average price of hay for the 10-year period 1905–1914, was $7.10 per acre.

The best yields of small grain have been obtained on corn ground. The growing of corn in the rotation has increased the yield of succeeding crops of barley and wheat more than it has the yield of oats. On account of its higher price wheat will usually produce a more profitable increase than barley. For this reason wheat should usually take precedence over barley on corn ground. If the price of barley should be the same as that of wheat or even slightly lower, the former crop would be preferable because the increase in the yield of barley due to placing corn in the rotation was 37 per cent of the crop grown in a system of continuous cropping, while the increase for wheat was but 33 per cent. Either wheat or barley can be grown to better advantage than oats on corn ground because of the fact that the increase in the yield of oats due to the placing of corn in the rotation was but 22 per cent of the yield where oats were grown continuously. The yield of oats following wheat and barley was almost equal to that on corn ground. Results at some of the other substations indicate that the increase in oat yields following corn grown on some soil types is greater than the increase obtained at Edgeley. All figures show, however, that oats do better following a small grain than does either wheat or barley.

The yields of small grains immediately following alfalfa and brome grass have been less than on land that had grown small grain

[1] N. D. Agr. Expt. Sta. Bul. 110, p. 190.

the preceding year. Corn and flax are usually better crops than wheat, oats or barley to be grown on sod. Brome grass and alfalfa take large amounts of water from the soil and unless there is considerable rainfall during the growing season succeeding crops frequently suffer from drought.

On the Fargo clay of the experiment station farm at Fargo the growing of timothy in the rotation has increased the yield of wheat 35 per cent. There was practically no increase the first year after timothy, but in later years there was a marked increase.

Sweet clover seems to be the most promising legume crop for the rotation in this region. Alfalfa can be worked into the rotation gradually. Land on which alfalfa has been grown for several years can be broken up and put in the rotation, and one of the fields that has been in the regular cropping system seeded to alfalfa. In this way alfalfa will have been grown on all the fields of the farm in the course of several years. While it will take a long time to get the beneficial effects of alfalfa on all parts of the farm, the manure produced when the alfalfa is fed can be applied to other fields so that the organic content of the entire farm may be maintained.

Weeds cause a considerable decrease in the yield of crops grown in the county and if they are to be controlled some cultivated crop like corn or potatoes must be grown. Seeding the land to grass or alfalfa will also help to eliminate many weeds. The greater economy of moisture and plant food when cultivated crops are grown systematically in the rotation will result in an additional increase in yield.

As an average of six years' results at Edgeley the application of nine loads of manure per acre to the fallow in a 4-year cropping system, consisting of fallow one year, wheat one year, corn one year, and oats one year, resulted in an increase of 3.6 bushels in the yield of wheat, 760 pounds of corn fodder, and 5.9 bushels of oats. In a rotation of fallow one year, oats one year, corn one year, and wheat one year the increase was 3.4 bushels of oats, 720 pounds of corn fodder, and 0.3 bushel of wheat, showing that greater returns are obtained from both wheat and oats when the former is grown the year following manuring.[1]

In a 4-year rotation arranged in the following order: Green-manure crop plowed under one year, small grain one year, corn one year, and small grain one year, no beneficial effects have been obtained from green manure in eight years' experiment at Edgeley. Rye, peas, and sweet clover were used as green-manure crops.[2] Probably better results would have been obtained had corn followed the green-manure crop. The cultivation of the corn crop would improve the structure of the soil for the production of small grain and facilitate

[1] N. D. Agr. Expt. Sta Bul. 110, pp. 188, 189.
[2] Ibid., pp. 186, 187.

decay. All things considered, it would not pay to give up the land one year for green manuring under present conditions. Large amounts of organic matter can be added to the soil in this way and eventually returns could be expected, but a smaller amount of organic matter can be added if a crop like sweet clover is grown in the rotation, the first crop being cut for hay. The second growth can be plowed under, but considerable organic matter is added even if this is cut. Small amounts of organic matter added in this way do not involve the loss of the use of the land, and the immediate results are sometimes better than if large amounts are plowed under.

SOILS.

The soils of the county are derived from glacial drift, either weathered in the position in which it was left by the ice or transported and redeposited in glacial lakes as terraces along glacial streams, or as recent alluvium. The drift of this region was deposited by the Dakota lobe of the great continental ice sheet during the Wisconsin stage of ice invasion, and ranges from a thin veneer to beds 80 or 90 feet in thickness. The composition of the material varies widely, the drift being made up of granite, limestone, shale, and sandstone of many formations and in various stages of attrition.

The upland drift has not been greatly modified by erosion, and the variations in the soil are due to differences in the original material or to weathering and the accumulation of organic matter. In the redeposited soils of the level lake beds and terraces, owing to the heavier growth of vegetation, larger quantities of organic matter have accumulated, so that the color of the material is relatively dark.

The soils of the glacial drift are classed with three soil series, the Barnes, Williams, and Edgeley. The Barnes series is characterized by dark-brown to black surface soils and light-brown to yellowish-brown, greenish-brown or grayish-brown, highly calcareous subsoils. The topography is level to rolling, and the greater part of the series constitutes good farming land. The Williams series is mapped on the Missouri Plateau, and is distinguished from the Barnes series by its slightly thinner black soil layer and by lighter colored subsoils. In plowed fields the soil color is often browner than that of the Barnes. The soil is productive, but the topography is often unfavorable for cultivation. The Edgeley series resembles the Barnes in color, but is underlain by a dark-colored shale rock within 5 feet of the surface, and contains considerable quantities of fragmental shale. This soil is comparatively unproductive.

The glacial-lake and river-terrace soils are classed with six soil series, the Sioux, Fargo, Rogers, Maple, Bearden, and Valentine.

The Sioux series has dark-brown to black soils and light-brown or yellowish-brown, calcareous subsoils, and is droughty because of a porous gravel substratum within a few feet of the surface. The Fargo series has a dark-brown to black soil and a gray to mottled gray and yellow, calcareous subsoil. The drainage is poor. The Rogers series is poorly drained and has a dark-colored soil with a light-gray or drab, calcareous subsoil, though there are large areas in which the soil is lighter colored, owing to the presence of alkali. This series usually is closely associated with the Edgeley, and is unproductive. The Maple series has a dark-gray or bluish-gray soil and a bluish-gray or gray, calcareous subsoil. It is underlain by gravel, but is poorly drained, occurring in depressions or old drainage channels. The Bearden series is mapped on high terraces along the James River Valley. The soils are dark brown to black and the subsoils yellowish brown and calcareous. The series is not droughty, and the material has a close, uniform structure something like loess. Where sand has been reworked and heaped up by wind action the resulting soils are very loose, incoherent, and droughty, and are classed with the Valentine series.

The first bottoms along the streams in Dickey County are seldom overflowed, because of the small volume of water in the drainage ways. The bottoms are classed with the Lamoure series. The surface soils are black to dark brown, with dark-colored, heavy, calcareous subsoils.

Areas which are too rough or rocky for agricultural use are mapped as Rough broken land.

List of series, showing origin and distinguishing characteristics.

Group.	Original material.	Distinguishing features.	Series.
Glacial	Unmodified drift.	Yellowish-brown subsoil; 1,300 to 1,700 feet altitude.	Barnes.
Do	do	Light-gray subsoil; 1,700 to 2,200 feet altitude.	Williams.
Do	do	The drift underlain by and mixed with shale.	Edgeley.
River flood plains	Recent alluvium.	Heavy, dark subsoil; large, flat bottoms.	Lamoure
Glacial lake and river terrace.	Old alluvium	Well drained; gravel substratum droughty	Sioux.
Do	do	Well-drained, silty, high river terrace, not droughty.	Bearden.
Do	do	Poorly drained; black soil; gray mottled subsoil.	Fargo.
Do	do	Poorly drained, dark-brown or drab soil; drab subsoil, underlain by gravel.	Maple.
Do	do	Poorly drained; gray or mottled subsoil; alkali; not deep to shale.	Rogers.
Glacial	Eolian deposits	Sand reworked and heaped by wind action; loose, droughty.	Valentine.

The following table gives the name and the actual and relative extent of each soil type mapped in Dickey County:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Barnes loam	230,400	31.5	Lamoure silty clay loam	7,936	1.1
Barnes silt loam	137,664	18.8	Lamoure clay	7,808	1.1
Williams fine sandy loam	56,000	7.7	Bearden fine sandy loam	4,480	.6
Bearden fine sand	36,416	5.0	Maple clay loam	4,352	.6
Williams loam	32,448	4.4	Bearden very fine sandy loam	3,968	.5
Fargo silty clay	32,000	4.4	Lamoure silt loam	3,904	.5
Barnes very fine sandy loam	29,248	4.0	Lamoure silty clay	3,840	.5
Valentine fine sandy loam	26,368	3.6	Bearden loamy fine sand	3,712	.5
Barnes silty clay loam	23,552	3.2	Lamoure very fine sandy loam	3,520	.5
Rough broken land	22,336	3.1	Sioux silt loam	3,008	.4
Sioux loam	12,224	2.4	Sioux sandy loam	1,408	.3
Colluvial phase	4,992		Colluvial phase	832	
Edgeley loam	16,000	2.2	Valentine fine sand	2,176	.3
Rogers silty clay	10,048	1.4	Bearden silt loam	1,472	.2
Sioux gravelly loam	1,984	1.1	Sioux fine sandy loam	640	.1
Colluvial phase	5,504				
Rolling phase	640		Total	730,880	

LAMOURE VERY FINE SANDY LOAM.

The soil of the Lamoure very fine sandy loam is about 16 inches deep, and consists of a dark-brown very fine sandy loam to fine-textured loam which is loose, smooth, and friable. The subsoil is a grayish-brown, friable, calcareous very fine sandy loam, grading into a slightly heavier, fine-textured loam, faintly mottled with gray. Still heavier strata occur at greater depths.

This type occurs mainly in the first bottoms of Maple River, which are overflowed about once in five years. One area lies along Bearden Creek, and a smaller one at the mouth of Cottonwood Creek. In many places the bottoms are hardly broad enough to be cultivated, and are used for pasture or hay land. Where farmed, the crops common to the region, wheat, corn, barley, and oats, are grown. Wheat yields about 16 bushels and corn 30 to 35 bushels per acre. The soil is well suited to corn, as it is deep and mellow. This type is usually sold with other soils, and its value is lowered somewhat by the irregular shape of the areas. It is held at about $35 an acre.

LAMOURE SILT LOAM.

The Lamoure silt loam is typically a dark-brown or grayish-brown, friable silt loam. Below a depth of 14 inches it gradually becomes more compact and slightly heavier in texture, and grades into a dark grayish brown silty clay loam or silty clay, slightly mottled with

grayish white at about 30 inches. The subsoil is highly calcareous. This is the lightest colored soil in the Lamoure series, and is sometimes light grayish brown at the surface. In places, especially along the Maple River east of Ellendale, it approaches a very fine sandy loam in texture. Along the James River it occupies the slight natural levees which often occur on the outside of large bends. This is an easy soil to cultivate, except that the fields are irregular in shape because of the meanders of the streams. It is naturally well drained, but is not droughty. It is particularly suited to alfalfa, because of the deep, porous soil and subsoil and the abundance of moisture in the deep subsoil. Corn and wheat and other small grains are grown, and the yields almost equal those on the Lamoure silty clay. This land is valued at $40 to $50 an acre.

LAMOURE SILTY CLAY LOAM.

The Lamoure silty clay loam comprises the undifferentiated material occurring in the flood plains of the smallest waterways and in the slightly lower areas which exist along some of the larger streams. The soil usually is dark brown to black in color, and ranges from a fine sandy loam to a heavy loam in texture. The subsoil below 12 or 16 inches usually is grayish brown, mottled with gray and brown, and varies in texture even more widely than the soil. Sometimes sandy or gravelly strata occur below 30 inches.

This type occurs along practically all the smaller streams, but the bottoms are sometimes discontinuous. The small areas are often included in fields with other, more extensive soils. The larger bottoms are used for pasture. Some wild hay is cut, yields of a little more than 1 ton per acre being obtained. The two large areas of this type associated with the Edgeley loam are a little better than other bottom soils in the same localities, but are not so productive as some more typical areas.

The value of this type depends on the surrounding land, and ranges from $20 to $35 an acre.

LAMOURE SILTY CLAY.

The Lamoure silty clay is a dark-brown to black, friable silty clay, which grades at about 16 inches into a dark-brown or dark-drab, compact silty clay to plastic clay. It is faintly mottled in the lower depths with light-gray material, which consists in part of soft lime concretions. This is an alluvial soil occurring along the James River, and at several points along the Maple River. It usually lies along the stream, especially in the bends. Good drainage results from the proximity of the river channel and from the gentle slope of the surface to the lower land occupied by the Lamoure clay.

This soil, though inextensive, is the most desirable type in the county. Because of its friability, it is easy to till. While well drained, it is able to withstand severe droughts. The principal crops grown are wheat, corn, and barley. In average years yields of 20 bushels of wheat, 35 bushels of corn, and 32 bushels of barley per acre are obtained. Alfalfa has been grown successfully on a small scale, giving three cuttings of about 1 ton each.

Farms consisting in large part of this type are valued at $50 to $60 an acre.

LAMOURE CLAY.

The soil of the Lamoure clay to a depth of 9 inches is a black or very dark drab clay which is plastic when wet and cracks or crumbles into angular fragments when dry. Below 9 inches the subsoil has much the same color and texture as the soil, consisting of dark-drab or brown clay slightly mottled with gray and becoming slightly lighter colored with depth. The subsoil is highly calcareous, effervescing strongly in acid, and commonly contains small pieces of shale.

Rather extensive areas of this type occur along the James River in the vicinity of Oakes and north of this place, with several small bodies near Ludden and at the state line.

The Lamoure clay is the most poorly drained type in the series. It usually occupies that part of the bottom farthest from the stream and adjoining the hills, where it receives drainage waters from the upland, the run-off of such water being prevented by the slight natural levee at the river bank. The wettest areas of the type are indicated on the soil map by the marsh symbol. In these wet places there is an accumulation of alkali which causes the land to have a somewhat lower value. The marshy areas support a dense growth of grass, which is cut for hay, yielding 1 to 2 tons per acre.

Where the type is drained it produces good yields of all small-grain crops, but it is not so desirable for intertilled crops, such as corn, because it is difficult to cultivate. Yields of 15 to 25 bushels of wheat, about 25 bushels of barley, 35 bushels of oats, and 25 bushels of corn per acre ordinarily are obtained. Crops are more certain in dry seasons on this type than on any other soil in the county. This type is valued at about $50 an acre.

BEARDEN FINE SAND.

To a depth of 16 to 20 inches the Bearden fine sand is a very dark brown to brown, loose, mellow fine sand or fine sandy loam. The subsoil is a lighter brown loamy fine sand, becoming yellowish brown, slightly mottled with gray and brown, and more loose and incoherent

in the lower part of the 3-foot section. The substratum consists of fine sand or coarser sand and extends to a depth of many feet. This type is the predominating soil in the region south of Oakes, but is not found in other parts of the county. The topography is level to very gently undulating. Along the north and west sides of the lake the type has a stronger, heavier, and more coherent soil, while toward the south and east it grades into the very loose "blow sands" mapped as the Valentine fine sand. The drainage is accomplished by the downward percolation of water, and the type is somewhat droughty. This type is too light in the subsoil for the typical Bearden soil, and not light enough for the typical Sioux. It could, however, be classed with either series. The area at Oakes and one near Ludden are coarser than the remainder of the type and slightly more droughty, while in a large area lying along the James River south of Oakes, the soil for a distance of about 2 miles from the river is finer in texture than the main body of the type. The soil here is nearer a very fine sand than a fine sand. The value of the type would be greatly increased if it could be devoted largely to alfalfa. When firmly established alfalfa would protect the surface from destructive erosion by winds, and its long tap roots would reach down to the abundant supply of ground water in the porous substratum within 10 or 15 feet of the surface. Experimental plots of alfalfa show that it can be grown in this region, though there is danger of the seed being covered too deeply and the small plants being smothered out in the loose surface before it is firmly established in the soil.

Soil moisture is easily conserved, so that corn does not suffer when the rainfall is well distributed. Small grain grows rather short and thin, and the heads are not large. Millet is a better source of hay than the native grasses. Yields of 8 or 9 bushels of wheat, 25 bushels of corn, 17 bushels of barley, 25 bushels of oats, and three-fourths to 1 ton of millet hay per acre are reported. The areas most subject to wind erosion are kept in grass, and yield about one-half ton of prairie hay per acre.

This soil type is also well suited to the production of corn and potatoes. Although it is apt to be droughty in some seasons for small grain, there is usually enough moisture for the production of cultivated crops. When cultivated crops are grown it is a good practice to cover the land with manure during the winter so that drifting will be checked in the spring. A fairly good crop of oats or durum wheat can usually be obtained on corn or potato ground handled in this way. Winter rye could be seeded in the stubble of this wheat or oats. If seeded very early in some years there would be moisture enough to obtain a stand of sweet clover. If a stand

is obtained it should produce a good crop of hay or seed or could be used for pasture. It makes especially good hog pasture. The sweet-clover land should not be plowed until the spring after the sweet-clover crop is produced. By following out some such cropping system drifting of the soil can be controlled to some extent. If the land is manured with 8 or 10 loads of manure per acre once in four years the soil will become more coherent in structure and less inclined to drift when such a cropping system is followed.

A demonstration farm was established on a sandy soil type similar to the Bearden fine sand in the vicinity of McLeod, in Ransom County, in 1909. The surface of the soil is more rolling and the sand is inclined to drift more than in the areas of this kind in this county, and the water table is nearer the surface on some parts of the farm. No rotation has been established on this farm, but experiments have been conducted to determine the adaptability of this soil for the production of various crops. These results have been obtained under conditions very similar to those in Dickey County and furnish an index of the adaptation of crops to sandy soils in the present survey.

The experiments have been carried on from 2 to 5 years and the number of trials has been from 3 in the case of field peas to 20 in the case of wheat.

The average yield of oats is 28 bushels, of field peas 9½ bushels, sugar beets about 11½ tons, potatoes 153 bushels, and of millet 1¼ tons. Winter wheat yields 8 and spring wheat 9½ bushels, respectively. Less extended trials with redtop show that where the water table is sufficiently near the surface yields of 1½ to 2 tons per acre of hay can be produced. Sweet clover has been grown successfully.

The average income per acre from all comparable crops in these experiments are as follows: Wheat, $7.51; oats, $8.26; barley, $6.65; rye, $5.75; flax, $11.05; potatoes, $84.55; and corn, $11.09.[1] The income derived from oats and barley covers the cost of production, flax and corn have a slight margin of profit, and potatoes are the most profitable crop grown.

The typical Bearden fine sand in this county is better suited to small grain than the soil of the McLeod demonstration farm, and such crops usually yield fairly well when grown in a rotation containing corn and alfalfa or sweet clover. Oats and durum wheat are probably the best small grains to grow.

This land is held for about $25 an acre.

[1] One and one-half tons of fodder is calculated as being worth as much as 1 ton of hay.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of this type:

Mechanical analyses of Bearden fine sand.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
351474	Soil	0.0	1.4	1.2	28.8	53.2	10.8	4.7
351475	Subsoil	.2	2.6	2.4	24.6	52.0	13.0	5.4

BEARDEN LOAMY FINE SAND.

The surface soil of the Bearden loamy fine sand is a dark-gray or black, loose, calcareous fine sand or loamy fine sand 8 to 10 inches deep. The subsoil to an average depth of 20 inches is a light-brown, loose, incoherent fine sand, below which depth it becomes yellowish brown mottled with gray and brown. The material of both sections of the subsoil effervesces in acid. There is seldom even a thin layer of heavier material in the soil section or substratum. The type is poorly drained, as it occurs in depressions, and even in dry seasons the sand is usually saturated at a depth of 3 or 4 feet. Unlike most depression soils, this type does not contain sufficient clay to make the sand coherent, and when the sod is broken the soil is likely to drift. On account of its moist nature and high water table, this land produces good crops of hay. Although some areas have been broken, most of them have reverted to grass, and furnish good hay and pasturage. During the summer of 1914, sec. 24, R. 59, T. 129, consisting largely of Bearden loamy fine sand, supported 280 head of beef cattle. Land of this type should yield 1 ton of prairie-grass hay per acre. Land of the Bearden loamy fine sand is valued at $20 to $25 an acre.

BEARDEN FINE SANDY LOAM.

The surface soil of the Bearden fine sandy loam typically consists of a black, dark-brown or dark-drab, loose fine sandy loam, 10 to 14 inches in depth. The subsoil is a light-brown or grayish brown, calcareous fine sandy loam, grading into a gray silty or sandy clay slightly mottled with drab and brown. This heavy layer usually gives way to a fine sandy loam heavily mottled with brown at 32 to 40 inches. The large areas of this soil 3 or 4 miles southeast of Oakes do not occupy distinct depressions, but have a very flat topography and a heavy layer in the subsoil that retards the downward percolation of rain water. The areas farther south of Oakes usually are depressed slightly below the general level of the plain and are not so well drained as the areas to the north. They are used mainly for

growing wild hay, yielding about 1½ tons per acre. Some alkali spots occur.

Land of this type near Oakes has a high value because of its convenient location as well as its good subsoil. It is a very good corn soil, as it warms up early in the season and is easy to cultivate. There is always an abundance of moisture under the loose surface soil. Wheat yields about 10 bushels and oats 20 to 25 bushels per acre. The wetter areas are kept in prairie sod and produce about 1 ton of wild hay per acre. Unimproved land of this type is valued at $20 to $25 an acre.

BEARDEN VERY FINE SANDY LOAM.

The typical soil of the Bearden very fine sandy loam is a dark-brown to black, very smooth, friable, and uniform-textured very fine sandy loam, with a depth of 12 to 16 inches. The subsoil is a dark grayish brown, highly calcareous very fine sandy loam, about 12 to 24 inches thick, changing rather abruptly to a light-gray, compact and somewhat impervious, highly calcareous silty clay or silty clay loam. This heavy layer continues below 3 feet, but changes to yellowish brown with depth. The topography is flat to gently undulating, and the surface drainage usually is good.

This type occurs in the southeastern part of the county within the smooth area known as the bed of Lake Dakota. The soil is composed of the fine sandy particles which have been washed or blown over heavier sediments laid down in the old lake or as river terrace material. The principal areas are located about 3 miles south of Oakes, 3 miles southwest of Ludden, and about 4 miles southeast and 4 miles north of this place.

This type is suited to all the general farm crops common to the region, and produces good yields. Corn yields about 20 bushels, wheat 10 to 15 bushels, and oats about 30 bushels per acre. Wild hay yields three-fourths ton and millet 1¼ tons of good hay per acre.

The soil of the Bearden very fine sandy loam is less likely to drift during high winds than other soils in this region, and it is unusually retentive of moisture.

This is a good corn and alfalfa soil, and millet and sweet clover can be used to good advantage in some cropping systems. The organic content should be maintained by the growing of alfalfa and sweet clover and the application of farm manure. Some of the rotations suited to this type are: (1) Corn or potatoes 1 year, wheat 1 year, oats 1 year, sweet clover 1 year, and alfalfa 4 years; (2) corn or potatoes 1 year, barley 1 year, oats 1 year, millet 1 year, and alfalfa 4 years; (3) corn or potatoes 1 year, millet 1 year, oats 1 year, sweet clover 1

year, and alfalfa 4 years; (4) corn or potatoes 1 year, barley 1 year, oats 1 year, sweet clover 1 year, and brome-grass pasture 4 years.

This is the most valuable soil of this part of the county. It is held at $30 an acre.

BEARDEN SILT LOAM.

The Bearden silt loam is a dark-brown to black, smooth, friable silt loam, with a depth of 10 to 16 inches, underlain by a yellowish-brown or oat straw colored, highly calcareous silt loam, which is slightly more compact and grades downward into a silty clay loam faintly mottled with gray and brown. The substratum usually resembles the subsoil, but fine sandy or gravelly layers may occur below 5 feet.

The type occurs mainly in the northeastern part of the county, the largest development being found south and southwest of Glover along the James River. This is a terrace soil and, while not eroded, usually is not level, but is gently sloping or undulating. It is often elevated more than 20 feet above the low bottom lands and probably was formed by the James River when it flowed at a much higher level, though the soil material has a structure resembling that of wind-laid deposits. It is essentially like the Barnes silt loam, differing only in the process by which the soil material was deposited.

The Bearden silt loam is a strong soil of good water-holding capacity, easy to till and suited to all crops usually grown in the region. Wheat yields about 15 bushels per acre, corn 35 bushels, and oats and barley in proportion. This land is valued at $40 an acre.

Results of mechanical analyses of samples of the soil and subsoil of this type follow:

Mechanical analyses of Bearden silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
351420	Soil	0.2	0.6	0.9	5.2	6.6	61.6	24.7
351421	Subsoil	.1	.4	.8	7.9	9.2	61.4	20.3

The following sample contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 351421, 15.20 per cent.

FARGO SILTY CLAY.

The soil of the Fargo silty clay is a black to very dark brown, friable to compact, usually calcareous silty clay 16 to 24 inches deep. It is sometimes faintly mottled with rusty brown. The subsoil is a

gray or drab, plastic, calcareous silty clay, becoming lighter in texture and heavily mottled with yellow, brown, drab, and light grayish with depth. This type is poorly drained and is so depressed that it receives the run-off from the surrounding land. The areas range in size from 2 or 3 acres to more than a section. The type is underlain by impervious clays or till where surrounded by glacial soils. Areas of the Fargo silty clay are scattered through all parts of the county, except on the well-drained east slope of the Altamont moraine. They are especially numerous near Clement and in the "hill country," or Altamont moraine. Where surrounded by the Williams soils the Fargo silty clay is less black and more drab in color than in typical areas. In some areas the black soil extends to a depth of 3 feet or more. One large area on the slope 4 miles south of Merricourt is similar to the Barnes silty clay loam, except that it has a decidedly ashy gray colored subsoil. A small area about 6 miles northeast of Fullerton, in secs. 1 and 36, Tps. 132 and 131, R. 61 W., is somewhat lighter in texture than the typical soil, and the same is true of a small area in section 20 of the former township, as well as of a long strip about 5 miles west of Ludden.

The majority of the areas of this type are too wet in the spring to be seeded to wheat, but are used for the production of hay. Hardly a farm is without one or more of these areas, which yield from 1 to 2 tons of prairie hay per acre. Since the run-off from the surrounding land has been greatly decreased by breaking the prairie sod and preparing a loose layer of soil which absorbs the rain, some of the areas of Fargo silty clay have become dry enough to cultivate. Good yields are obtained, although where grain is grown the straw tends to grow too rank, and corn is subject to injury by early frosts. In favorable seasons wheat yields about 30 bushels, corn 25 to 30 bushels, oats about 70 bushels, and barley about 40 bushels per acre in the better drained areas.

An average value of this type, based on its use for hay, is $25 to $30 an acre.

Average results of mechanical analyses of samples of the soil and subsoil are given in the following table:

Mechanical analyses of Fargo silty clay.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
351446, 351496.....	Soil.....	0.5	2.1	1.9	9.2	7.6	44.0	34.8
351447, 351497.....	Subsoil.....	.1	.6	.6	3.3	9.6	55.9	30.0

The following samples contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 351447, 20.29 per cent; No. 351497, 16.88 per cent.

SIOUX LOAM.

The Sioux loam is a light to heavy loam, very dark brown to black in color, the black layer having an average thickness of about 12 inches, though in exceptional cases it extends to a depth of 2 feet or more. The subsoil is a yellowish or grayish-brown, calcareous loam and there is in many places a compact layer just above the gravel substratum. The gravel is often incrusted with lime. The type is fairly retentive of moisture. This soil occurs typically on flat terraces along Bearden Creek and other watercourses where beds of gravel were deposited in glacial times. Wherever the type occurs along the outer boundary of a valley, especially along James River and Bearden Creek, it has received more or less wash from the adjacent hills covering the original river terrace with a layer of silty material. This material is essentially the same as that beneath, so far as its source and composition are concerned, though the greater part of the accumulated wash is dark in color, making the dark-colored layer thicker and also burying the gravel layer deeper than in the uncovered terraces. The soil is somewhat better, therefore, than the typical soil, though the moisture supply may not be the same. The topography is sloping rather than flat. The areas northeast of Oakes are slightly lighter in texture than elsewhere.

The Sioux loam has a good, loose, porous structure, even where it is broken when wet, and is easily worked into a good seed bed. The soil contains about 10 per cent of organic matter and is quite productive. Yields are reduced by the droughtiness of the soil and are slightly lower than on the Sioux silt loam. Corn yields about 25 bushels, wheat 12 bushels, barley 20 bushels, and oats 27 bushels per acre. Unimproved land of this type sells for about $30 an acre.

Sioux loam, colluvial phase.—Along the foot of the Altamont moraine a belt of soil is mapped as the Sioux loam, colluvial phase. This belt does not extend along a stream, but is traversed by a number of streams, which flow directly across it. This is colluvial material which is mapped as Sioux because of its water-laid origin and the occurrence of a layer of gravel a few feet below the surface. It is a loam in texture and has the other characteristics of the Sioux loam. Its topography and the crops grown on it, as well as the yields obtained, are about the same as on the typical soil. This phase is shown on the soil map by parallel rulings over the Sioux loam color.

SIOUX GRAVELLY LOAM.

The Sioux gravelly loam is a dark-brown to black, calcareous gravelly loam or sandy loam grading at 2 to 6 inches into an earthy gravel bed with lime-incrusted pebbles, and at greater depths

into cleaner and looser gravel. The gravel particles are from one-fourth inch to 5 or 6 inches in diameter. The topography usually is level, but some areas occur on small ridges or along the slopes of terraces.

This type is not suited to crop production, because it is too gravelly to cultivate and too droughty to produce profitable crops. It furnishes scant pasturage. The underlying gravel beds are sources of good road-surfacing material and railroad ballast, but the gravel does not make good concrete, because it contains soft shale pebbles. For farming the type is valued at about $10 an acre.

A beach-sand variation of this type is developed in a number of places, mainly in the higher country west of the Altamont escarpment. It is found in very narrow belts that were originally small, permanent lakes. Most of these areas have become mere marsh land on account of the decreased inflow of water due to the breaking up of the prairie sod and the resulting greater absorption of the rainfall by the soil. These belts consist of 4 to 6 inches of a loose gravelly loam or sandy loam top layer, usually dark brown in color, underlain by a loose gravel subsoil. The soil is very rarely cultivated. Yields of small grain do not average more than 5 or 6 bushels per acre. The soil usually is covered with grass in its native condition, though the more recently formed areas are barren of vegetation.

Sioux gravelly loam, colluvial phase.—In character of soil this phase does not differ essentially from the main type. It is black or dark brown in color and gravelly to sandy in texture, and is underlain by gravel. It lies at the foot of the Altamont moraine, stretching as a narrow north and south belt in Tps. 129 and 130, R. 65 W., with smaller areas north of the main belt. This belt extends across rather than along the minor drainage ways. It slopes eastward and has a somewhat steeper surface than the typical soil. It is slightly eroded in places. Agriculturally it has about the same value as the typical soil. (See Pl. I, fig. 2.)

Sioux gravelly loam, rolling phase. –The soil of the Sioux gravelly loam, rolling phase, is a very dark brown to black gravelly loam or gravelly sandy loam, with a depth of 4 to 6 inches. The subsoil is a grayish-brown, earthy gravel, grading quickly into beds of stratified gravel, which are grayish, yellowish or rusty brown in color, usually effervescing freely in acid, and containing as a rule many lime-coated pebbles.

This phase occurs on small, rounded kames and long, narrow eskers where the water escaping from the glacier front or flowing through cracks in the ice sorted and deposited the material of these gravelly hills. It is scattered over the county, usually associated with morainic hills, especially in the low hills of the Antelope moraine, which extend through the county west of Ellendale and near Monango. It

is a poor soil and is seldom cultivated except where the knolls are very smooth and occur in a field made up mainly of good soil. Because of the droughty nature of the subsoil, the yields of all crops are light, and even the prairie grasses make a poor growth. The phase is worth very little for farming, but is a source of good road-building material.

SIOUX SANDY LOAM.

The typical Sioux sandy loam is a brown, dark-brown or black, loose, medium sandy loam or loamy sand, 8 to 12 inches deep, underlain by a loose and incoherent medium sand, yellowish or grayish brown in color, and grading into coarse sand or fine gravel. This soil was formed by weathering and the accumulation of vegetable matter on the sand bars of glacial streams. The topography is generally level. The type occurs along the James River and some of the other streams of the county. Like the fine sandy loam, neither the soil nor the subsoil usually effervesces in acid.

The typical soil and the colluvial phase, described below, have about the same value, ranging from $20 to $25 an acre. They are also about equal in productiveness, yielding 7 to 9 bushels of wheat, about 18 bushels of corn, and 15 to 20 bushels of oats per acre.

Sioux sandy loam, colluvial phase.—Several small areas of the Sioux sandy loam occur on colluvial slopes at the foot of the Altamont moraine, in the western part of the county. The soil of these areas is the same in character as the typical, the only difference being in its position at the foot of the slope, where it has been laid down as colluvial wash rather than as a terrace. The topography is smooth.

SIOUX FINE SANDY LOAM.

To a depth of 8 to 12 inches the Sioux fine sandy loam is a loose, mellow fine sandy loam. The subsoil is a light-brown to yellowish-brown fine sandy loam, becoming somewhat heavier and more compact with depth. While the type occurs on a gentle colluvial slope, the rather uniform sandy nature of the soil indicates that much of it was carried there by the wind, instead of being derived entirely from the heavier material of the hills above.

The Sioux fine sandy loam is mapped in several areas along the upper course of the James River. The substratum of the type usually is composed of sands instead of gravel and the subsoil does not seem to be so calcareous as most of the soils in this region. It rarely effervesces in acid.

This type is of too small extent to be of general importance, but it produces fair yields of all the crops common to the region. Wheat yields about 11 bushels, and other crops give proportionate yields per acre. This land is held for about $25 an acre.

SIOUX SILT LOAM.

The Sioux silt loam is the heaviest member of the Sioux series in Dickey County. The soil is a dark grayish brown silt loam containing considerable sand. At 10 to 16 inches this grades into a light-brown or yellowish-brown silt loam or heavy loam. The subsoil usually is more compact and heavier in the lower part and a bed of gravel is encountered at a depth of 30 to 40 inches. Both soil and subsoil are sufficiently calcareous to effervesce in acid.

This soil is typically developed at several points along the James River and Bearden Creek. The area 2 miles northeast of Oakes is lighter than typical, approaching a very fine sandy loam, and is underlain by beds of sand. Several areas of the type mapped along small draws on the slope below the Missouri Plateau merge with the adjoining soil in such manner that they can be located only by boring down to the gravel beds. They occupy positions essentially like those occupied by the colluvial phases of some of the Sioux types, and could have been separated as colluvial phases of the silt loam if of sufficient extent.

This type is not very droughty, owing to the thick layer of close-textured soil and the slight tendency toward a hardpan just above the gravel beds. It is well drained and is an easy soil to handle. In seasons of average rainfall it produces practically as good crops as the Barnes soils. Wheat yields from 15 to 25 bushels, oats 30 to 50 bushels, flax 6 to 7 bushels, barley 25 to 40 bushels, and corn about 28 bushels per acre, in favorable years.

This type sells for $30 to $40 an acre, or more where the farm improvements are good.

ROGERS SILTY CLAY.

The Rogers silty clay is a variable type, but the average soil is a very dark brown or dark-drab to black, calcareous silty clay to clay 10 to 14 inches deep and slightly mottled with gray. The subsoil is a dark-gray, compact, plastic, highly calcareous silty clay, mottled with gray and yellowish gray below 24 inches. There are heavy black "gumbo" spots in places, and in other places a yellowish clay is encountered near the surface. The surface is often veneered with streaks or spots of sand and is light gray with the alkali incrustations associated with the type. In places the underlying clays directly overlie bedded shale and elsewhere they pass into till. The Rogers silty clay occurs mainly in areas within or near the strip of Edgeley loam west of Monango and Ellendale, where it occupies wide flats.

A variation of the Rogers silty clay occurs on the Plateau as the lake-bed deposits of depressions which recently contained several feet

of water. Such areas resemble the Fargo silty clay, but are more highly impregnated with alkali. Most of the type is used for pasture or hay land, though some of the smaller areas occurring within bodies of Barnes soils are cultivated. They are too wet and cold to produce good crops of corn, and the alkali seems to stunt the growth of small grains. The type supports a growth of coarse grasses. This land is valued at $15 to $18 an acre.

Below are given the results of mechanical analyses of samples of the soil and subsoil of the Rogers silty clay:

Mechanical analyses of Rogers silty clay.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
351416	Soil	1.0	3.0	2.4	15.9	19.0	28.6	30.0
351417	Subsoil	.6	1.4	1.2	10.2	15.6	34.3	36.4

The following samples contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 351416, 6.29 per cent; No. 351417, 23.36 per cent.

MAPLE CLAY LOAM.

The Maple clay loam has a dark-drab clay loam soil, 8 to 15 inches deep, and a drab, close-structured, waterlogged subsoil which becomes lighter drab and mottled with gray and brown at about 30 inches, where it usually grades into gravelly or sandy strata. This gravel does not subdrain the soil, because the type occurs in the bottoms of old drainage channels or lakes. Where it occupies long, comparatively narrow troughs there is some surface drainage by streams, and the soil is somewhat lighter textured, but where it occupies lake beds the drainage is poorer and the soil is often a silty clay in texture.

Areas of the Maple clay loam occur in the northeastern corner of the county. An area occurs between Fullerton and Ellendale, and several areas are mapped in the vicinity of the Edgeley loam. Two areas of a heavy variation are encountered in German Township, in the western part of the county.

Owing to its poor drainage, this type is not extensively cultivated. It furnishes some pasturage and produces about a ton of prairie hay per acre. Where cultivated the yields average 7 or 8 bushels of wheat, about 15 bushels of barley, and 18 bushels of oats per acre. The soil is not suited to corn. This type ranges in value from $10 to $25 an acre, according to the drainage and the value of adjoining land.

BARNES VERY FINE SANDY LOAM.

The Barnes very fine sandy loam consists of 10 or 12 inches of dark-brown to black, loose, mellow very fine sandy loam or fine-textured loam, underlain by a lighter brown, loose, porous loam which grades at about 24 inches into light-yellowish or grayish-brown loam or fine sandy loam. This lower material effervesces freely in hydrochloric acid. The subsoil and substratum usually have the same texture and structure, but in places the material becomes heavier and more compact with depth. Several areas, associated with old drainage ways about 6 miles northeast of Oakes, are characterized by unusually deep, smooth, uniform-textured soils, possibly of wind-blown origin.

The largest areas of this type occur around Monango and along the upper course of the Maple River. Other areas are found north and northeast of Fullerton, west and southwest of Ellendale, and scattered along the slope west of the Edgeley loam. The topography is level to gently undulating, and the type is well drained by draws, depressions, and a porous substratum. Areas of this type merge with the Barnes loam on the one hand and with the Valentine fine sandy loam on the other, and each type includes small areas of the others.

The Barnes very fine sandy loam is a strong soil, but crops suffer from prolonged droughts. While the wind shifts the surface material in plowed fields to some extent, it does no appreciable damage. The land is easily broken and cultivated. Land which has been devoted to small grains for several years is infested with Russian thistle and other weeds, but these can be largely eradicated by growing cultivated crops or millet. This type averages a little stronger and more retentive of moisture than the Valentine fine sandy loam, and is slightly less productive than associated areas of the Barnes loam. Corn should be planted to a greater extent on this type. It averages about 24 bushels, with maximum yields of about 35 bushels, per acre. Millet yields 1½ tons per acre when the hay varieties are sown, while hog millet yields 20 to 25 bushels of seed per acre. Wheat yields average 9 or 10 bushels per acre, ranging from 3 or 4 bushels in dry years to 15 or 16 bushels in more favorable seasons. Oats average 20 to 25 bushels, barley about 16 bushels, and winter rye 13 or 14 bushels per acre.

This land has an average value of about $30 an acre, with a higher value where it is highly improved and favorably located with respect to markets and shipping points.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the Barnes very fine sandy loam:

Mechanical analyses of Barnes very fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
351402	Soil	1.6	6.0	5.6	30.5	16.2	32.2	7.4
351403	Subsoil	.8	4.4	5.2	37.6	15.2	23.8	12.8

The following sample contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 351403, 4.25 per cent.

BARNES LOAM.

The Barnes loam is a dark-brown to black, mellow loam, 8 to 12 inches deep, underlain by lighter brown, yellowish-brown or greenish, highly calcareous, moderately compact loam. The substratum is somewhat heavier and more compact and consists of glacial till, resting upon shale. The till is 5 to 20 feet thick near the Edgeley loam and 80 to 100 feet or more in thickness in the eastern part of Dickey County. There are several variations of this type. As mapped in Barnes County, N. Dak., it occurs on and about morainic areas, and a similar development is found in a few places in Dickey County. In such places it has a slightly thinner soil than typical, a rolling and hilly topography, and a relatively large number of stones and bowlders on the surface. Such areas occur east of Oakes and south of Guelph. Practically these same characteristics are found where the type is mapped in the old drainage way or spillway just west of Clement. Many of the small areas of this type scattered through areas of the Barnes silt loam consist of small, eroded, and stony hills or knobs. As a rule these areas have a comparatively heavy and compact subsoil, which is often mottled with gray. Although stones are numerous on the surface, they do not interfere seriously with cultivation and can be removed economically. This variation of the type is less valuable than the Barnes silt loam.

Another variation of the Barnes loam is encountered in the James River Valley and in Ada Township, where it corresponds closely in depth of soil, texture and structure of subsoil, topography, and general agricultural value to the adjoining areas of the Barnes silt loam. The only difference is that the soil is somewhat coarser textured. These areas constitute good agricultural land.

A variation is found along the Maple River and between that stream and the belt of Edgeley soils. Here the type is associated with areas of very fine sandy loam, and the areas of Barnes loam often contain spots of other material which are too small and unimportant to map separately. The subsoil and substratum are lighter, looser, and more porous than typical. The topography is generally level to gently undulating, except where the monotony of the plain

is broken by the low, rounded hills of the Antelope moraine. These hills occur as small knobs and discontinuous ridges in a strip passing 5 or 6 miles west of Ellendale and a little west of Monango. Where this variation of the Barnes loam is associated with the Edgeley and Rogers soils it is less valuable, but it grades into better, stronger land toward the east. The Barnes loam occurs east of the Altamont escarpment and is the predominant soil in ranges 61, 62, 63, and 64.

In a general way the type of farming on the Barnes loam is the same as on the silt loam of the series. The two types merge so gradually that the boundaries are necessarily arbitrary in many places. However, the loam on the average is somewhat less productive for all classes of crops than the silt loam.

The areas of the Barnes loam of rougher topography form an extensive area in prairie sod, which furnishes good pasturage or yields about a ton of hay per acre. Whenever the sod is broken the land is put in flax, which yields an average of 7 bushels of seed per acre. On the lighter variations near Ellendale many farmers have found hog millet to be a paying crop, averaging 25 bushels of seed to the acre. In addition, this crop may be seeded late, and it protects the ground from strong winds. Some farms on the Barnes soils are so badly infested with wild oats that yields of wheat and other small grain are decreased and millet is an excellent crop for such lands. Wheat averages 10 or 11 bushels on the lighter and more droughty areas and 13 or 14 bushels per acre on the better areas. In favorable years yields of 25 to 30 bushels have been obtained. Barley sometimes produces as much as 40 bushels per acre, but the average yield is about 20 bushels. Oats average 30 bushels, with occasional yields of 50 to 70 bushels per acre.

The Barnes loam is suited to much the same range of crops as the Barnes silt loam. At present it is cropped in much the same way. Being a coarser textured type it will require even more care in maintaining the organic matter. Some areas of this type will require special attention to avoid drifting or blowing, especially in the spring, although several other types in the county will require even more care than this in that respect. Broom-corn millet is grown quite successfully by some of the farmers in the county on this type. This is one of the best corn soils in the county, and alfalfa can be grown successfully on much of it. It is not as good a soil for small grain as the Barnes silt loam, and cultivated crops and forage crops will need to be grown more frequently in the rotation.

A demonstration farm was located on this soil type near Jamestown, in Stutsman County, in 1901.

The land was broken up in the spring of 1880 and cropped to small grains continuously with the exception of 1905, when it was summer fallowed. Wheat

was grown each of the following years until the spring of 1910, when it was taken for demonstration farm purposes. During all the time it was cropped no manure or other fertilizer had been applied to the land. The farm was thoroughly infested with wild oats and yellow mustard.[1]

The rotation planned for this farm consisted of corn, 1 year; wheat, 2 years; clover or oats and peas, 1 year; and winter rye, 1 year. Ten loads of stable manure per acre were applied to the land for the corn crop. The last of the plots was manured for the 1913 corn crop and plot 2 has been manured the second time. The average yield per acre for the 6-year period was, wheat, 16.60 bushels; corn, 26.91 bushels; oats and peas, 2,000 pounds; and rye, 9.58 bushels.

The crop in 1909 was seriously injured by a hailstorm on July 31. In 1910 the rainfall was very light, so that the yields were low. The early part of the season of 1911 was quite dry, and there was very little available water stored in the soil because of lack of rain the preceding year. In addition to this the wheat crop was injured by rust. A good corn crop was produced in 1911, and the wheat on land that had grown corn the preceding year was fair. The last three years have been quite favorable. Corn has ripened in four years of six and produced a fair crop of fodder in 1912. The wheat crops have been fairly good. The wheat crop immediately following the corn crop has produced an average of over 4 bushels per acre more than that grown the second year after the corn. Timothy and clover have been seeded each year with the second wheat crop, but a stand has been obtained in only 2 years of the 6. Oats and peas produced fair crops in 1909 and 1912, but yielded very little in 1910 and 1911 because of the dry weather. Winter rye has not given good results when seeded on land that grew peas and oats the preceding year.

During the years 1913 and 1914 the cost of producing the various crops in this rotation was calculated. As an average for the two years it has cost $11.88 to produce an acre of corn in this rotation, $8.19 to produce an acre of wheat following the corn, $7.03 to produce the second crop of wheat, $5.07 per acre to produce clover and timothy, and $7.57 to produce an acre of barley. The average income per acre was, wheat, first year following corn, $12.01, or second year after corn, $8.99, corn $15.39, oats and peas $10.41, and rye $5.70.

While the corn crop has not shown a profit every year, it has produced enough in the good years so that as an average it has returned a profit. In fact it has been almost as profitable as the wheat crop which followed it, and the profit obtained from the wheat is largely due to the cultivation given to the corn the preceding year. This

[1] Third annual report of the Superintendent of Demonstration Farms for North Dakota, 1909, p. 36.

is supported by the fact that the first wheat crop following the corn returned on an average a profit of $3.81 per acre while the second returned but $1.86. This would indicate that 51 per cent of the profit obtained from the first wheat crop was attributable to the fact that corn instead of wheat preceded it. All things considered the corn crop has been the most profitable of any in the rotation for the entire period. The timothy and clover crops have returned a good profit in the years when a stand has been obtained, but a stand has been obtained but two years in five. For comparison the value of the fodder has been calculated in the years that ripe corn was produced. This amounted to $6.04. It will be noted the crop is much more valuable when calculated on the basis of husked corn. This shows that it is much more profitable to grow a variety of corn that will ripen than to grow a late-maturing variety that will make only fodder.

Other rotations that could be followed on this soil type are as follows: (1) Corn 1 year, wheat 1 year, oats 1 year, and alfalfa 3 years; (2) corn 1 year, wheat 1 year, broom-corn millet 1 year, and alfalfa 3 years; (3) corn 1 year, barley 1 year, oats 1 year, and alfalfa 3 years; (4) corn 1 year, broom-corn millet 1 year, wheat 1 year, and timothy and clover 1 year; (5) corn 1 year, wheat 1 year, barley 1 year, and sweet clover 1 year.

Alfalfa is the best legume crop for this type and by having four fields, one of which is in alfalfa for three years, it can be worked into the rotation. It is possible that in some cases more than two grain crops can be grown after a cultivated crop, but most of the available data indicate that the third and succeeding crops are very uncertain, and the chances are against their being profitable.

The Barnes loam has an average value of about $33 an acre for the land alone, but the improvements sometimes have a greater value than the land. Some good farms on this type are held for more than $60 an acre.

BARNES SILT LOAM.

The Barnes silt loam is a dark-brown to black silt loam to heavy loam, underlain at an average depth of about 12 inches by a lighter brown or yellowish-brown silty clay loam or loam, often showing a shade of green and always highly calcareous. The deeper subsoil usually is somewhat heavier and spotted with accumulations of soft lime carbonate. Some crystalline stones and bowlders occur on the surface and in the soil. About 10 per cent of the rock fragments on the surface are limestone, and the rocks embedded in the soil usually are incrusted with lime. The subsoil, at depths ranging from 1 to 2½ feet, effervesces with acid. The drift giving rise to this type was

laid down under the ice sheet, where it was leveled and subjected to the action of water from the melting ice.

The topography is level to undulating and the land usually is well drained as a result of the natural slope and existence of many depressions. On slopes the soil layer is often thinner than typical, and in sags the dark-brown color may extend to a depth of 20 inches. Practically all the type is available for agriculture, and it constitutes the best upland soil in the county. Farm buildings are good and there is a general appearance of prosperity in regions where the Barnes silt loam is the prevailing type. It comprises the greater part of the glacial soil of Wright, Yorktown, Hudson, Port Emma, James River Valley, Clement, and Bear Creek Townships. Several sections of this type occur 5 to 8 miles north of Fullerton; a large body lies between Ellendale and the Maple River; and other important areas occur on the gentle slope below the Missouri Plateau. In many places it is difficult to separate this type from the adjoining Barnes loam. These two soils are comparable in physical characteristics and in general value. However, the Barnes silt loam is very seldom spotted or associated with sandy loam soils, while patches of such soils are common in areas of the Barnes loam.

The Barnes silt loam soil has a very smooth feel, due to the 10 to 15 per cent of organic matter present. This high organic-matter content sometimes causes the soil to seem lighter than it really is, while on the other hand it masks the sandiness of lighter phases of the type. Heavier phases clod when plowed too wet, but the clods are fairly easy to pulverize by disking and harrowing. Both the soil and subsoil are retentive of moisture, as is the underlying till, which extends to depths of 20 to 100 feet before shale is encountered. Only insignificant alkali spots occur in this type.

From 70 to 80 per cent of the area of this type is devoted to small grains, while something less than 10 per cent is used for hay or forage. In this system of grain farming it is often necessary for the farmers to buy feed for the work stock. Wheat is the leading cereal and the chief money crop. Taking good and bad seasons the yield averages about 15 bushels per acre. Some of the best land often produces more than 20 bushels per acre, and yields of 35 to 40 bushels are sometimes reported. Barley would probably give better yields if it were given the same attention as wheat. Even with late seeding it averages 22 bushels per acre, and under exceptionally favorable conditions it produces 40 to 45 bushels. Flax, the crop usually sown on newly broken land, yields an average of 8 or 9, with a maximum of 15 to 20, bushels per acre. The acreage of corn is steadily increasing as the bad effects of growing wheat year after year on the same land are more generally recognized. Early maturing varieties well suited to this climate are being introduced, and many silos are being

erected. The average yield per acre is about 28 bushels, but 40 bushels or more may be obtained. A large acreage of oats is grown each year, chiefly for horse feed. Oats ordinarily yield about 32 bushels per acre, with maximum yields of about 50 bushels on the best land during favorable seasons. Potatoes are grown for home use and to supply local markets. They average nearly 90 bushels per acre, and some farmers report yields of 150 to 200 bushels. The number of cattle kept on this type is increasing. Millet and brome grass yield about 1½ tons of hay per acre. Timothy and clover are of minor importance and yield about a ton of hay per acre. Alfalfa is grown on a very small scale, and yields about 2 tons of hay per acre. This crop should have a more important place in the present system of farming.

The Barnes silt loam has a comparatively high water-holding capacity. The upper 40 inches of the soil is capable of retaining the greater proportion of the average rainfall of the region. For this reason there is very little percolation through this soil, and if the surface material is kept in a granular condition, so that it will absorb the rainfall, there need be little loss of water where the crops are grown in such sequence that the water in the soil will be utilized and not allowed to evaporate.

This soil is especially suited to small-grain production, but as these crops have been grown almost exclusively since the land was broken, satisfactory yields have not always been obtained on some farms on this soil type in recent years. In its native state this soil contained a large amount of organic matter. Practically no manure has been added and very few grass or legume crops grown to keep up this supply. The only organic matter remaining is that which has withstood decay during the time the land has been under cultivation.

The soil must be improved by the growing of legume and grass crops and cultivated crops in the rotation. In addition to this all roughage, such as straw, etc., should be converted into manure and returned to the soil. Corn or some other cultivated crop should be grown once in four or five years, and if possible some hay crop should be grown at least that often. Alfalfa could be worked into the rotation slowly by leaving it down for four or five years and then plowing it under and using on this field the rotation followed on the remainder of the farm. Alfalfa can be grown on another field in the meantime. The manure produced when the alfalfa is fed can be applied to such parts of the farm as may be in need of it in order to be kept in a well-balanced state of fertility.

A demonstration farm has been located on this soil type in the N. W. ¼ sec. 30, T. 131, R. 59 since 1910.

The time it was broken up as prairie sod is unknown, but it probably was in the early eighties. Since the spring of 1910 it has been cropped with wheat,

oats, barley, and millet. It has never been manured. It has never been in a cultivated crop, and is not infested with any noxious weeds with the exception of wild oats, although these are quite abundant.

A 5-year rotation consisting of corn, 1 year; durum wheat, 1 year; oats or winter rye, 1 year; Blue-stem wheat, 1 year (nurse crop for timothy and clover); timothy and clover or oats and peas, 1 year, was planned for this farm. This rotation has been followed as closely as possible. Ten loads of stable manure per acre have been applied to the land for the corn crop. The last of the five plots was manured for the corn crop of 1914.

It will be noted that corn has ripened in four years of the five, the average yield being 24.25 bushels. When figured at the average farm price for corn in North Dakota in the years in which it was grown, this gave an average return of $12.13 per acre. Valued at its fodder equivalent, the crop was worth but $6.13 per acre, 1½ tons of fodder being considered equal in value to 1 ton of hay.

Durum wheat following the corn has produced an average yield of 20.49 bushels per acre, worth $16.58. This crop was grown in the best place in the rotation for small grain, and returned a larger income than any other crop in the rotation. Oats were grown in 1910 and 1911, two very dry years, so that the yields are no doubt below what could be expected in an ordinary year on this soil type. Rye grown in 1912, 1913, and 1914 produced an average yield of 18.41 bushels, worth $10.88. Blue-stem wheat following oats or rye has averaged but 11.81 bushels per acre, worth $9.42.

All crops were produced at a good profit in 1912 and a fair profit in 1913. With the exception of the millet hay, all crops returned a good profit in 1914. As an average durum wheat has been the most profitable crop. This is largely due to the fact that it occupies the place in the rotation that is most favorable for small grain, and a large part of the profit is attributable to the cultivation given the corn crop during the previous season.

Some other rotations suggested for this soil are as follows: (1) corn 1 year, wheat 1 year, wheat 1 year, oats 1 year, alfalfa 4 years; (2) corn 1 year, wheat 1 year, barley 1 year, oats 1 year, brome 4 years; (3) corn 1 year, wheat 1 year, broom corn 1 year, barley 1 year, alfalfa 4 years; (4) corn 1 year, wheat 1 year, wheat 1 year, oats 1 year, alfalfa 4 years; (5) corn 1 year, wheat 1 year, oats 1 year, winter rye 1 year, alfalfa 4 years; and (6) corn 1 year, wheat 1 year, winter rye 1 year, oats 1 year, and oats and peas (hay) 1 year.

While these rotations might not be suited to many farms on this type of soil at this time, they could be followed with profit on many, if the farm could be supplied with the necessary live stock.

The average value of the Barnes silt loam is about $37 an acre, but some well-improved farms are held for as much as $75 an acre.

Results of mechanical analyses of samples of the soil and subsoil of the Barnes silt loam follow:

Mechanical analyses of Barnes silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
351454	Soil	0.5	2.5	2.0	10.5	16.9	53.0	14.4
351455	Subsoil	1.3	3.3	2.4	12.7	15.4	42.1	22.8

BARNES SILTY CLAY LOAM.

The soil of the Barnes silty clay loam, to a depth of 10 to 12 inches, is a black or very dark brown silty clay loam. This is underlain by dark grayish brown or drab silty clay loam or silty clay which with increasing depth gradually becomes yellowish brown mottled with gray and rusty brown. This type occurs in shallow depressions in positions much like those of the Fargo, but the soil differs from the latter in having better drainage. Around and north of Forbes there are areas of this type so large that their occurrence in depressions is not perceptible. Such areas apparently were formed by the deposition of the finest materials carried by the small streams which rise in the hills. These small streams may disappear in a wide flat of the silty clay loam from which one or more draws continue the drainage toward lower lying land, eventually joining the Elm River. There is a slight ridge of the Barnes silt loam just east of Forbes which cuts off the drainage in that direction and is largely responsible for the formation of considerable areas of this type. In this section of the county the Barnes silty clay loam merges with the silt loam type, and the two soils are difficult to separate. Spots of both heavier and lighter soil are of common occurrence in this type. Some areas of the type are heavy enough to cause difficulty in cultivation, except at times when the moisture conditions are just right.

The Barnes silty clay loam has about the same crop-producing power and the same average value as the Barnes silt loam. Wheat yields 12 to 15 bushels, oats 27 to 30 bushels, barley 18 bushels, and corn about 25 to 30 bushels per acre, under present systems of management. This type has a much greater productive capacity than these yields would indicate, and would produce better yields if the

land were cleared of weeds and crops grown in proper rotation. This soil is more difficult to cultivate than other members of the Barnes series.

Areas of this type near Forbes are valued at about $25 and those near Kulm at $30 or more an acre.

Results of mechanical analyses of samples of the soil and subsoil of the Barnes silty clay loam are given below:

Mechanical analyses of Barnes silty clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
351404	Soil	0.2	0.6	0.6	4.3	10.3	50.2	33.6
351405	Subsoil	.2	.4	.4	2.5	10.6	53.0	32.9

The following samples contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 351404, 1.22 per cent; No. 351405, 1.93 per cent.

WILLIAMS FINE SANDY LOAM.

To a depth of 10 or 12 inches the soil of the Williams fine sandy loam is a dark-brown to very dark brown, mellow or loose fine sandy loam. The subsoil is a light-brown fine sandy loam to loam, quickly becoming light gray in color or heavily spotted with grayish white with depth. The subsoil effervesces in acid, and the soil occasionally shows faint effervescence.

This type includes several variations. The greater part of it has a rolling to rough morainic topography, with an abundance of stone on the surface and with large quantities of coarse sand and fine gravel in the soil. Near the Plateau and on its east slope it is often difficult to separate this type from Rough broken land, and the boundary between the two is more or less arbitrary. Notwithstanding the loose structure and the texture of this type and its steep slopes, it is not subject to erosion, because of its heavy sod and high organic-matter content and the lack of heavy rainfall in this region. Some areas of the type have a more uniform texture and smoother topography. Such areas occur in the vicinity of large depressions, and seem to have been modified by sand blown from the beaches. In places the subsoil is not uniformly gray, and the sand is quite deep. One large area of this kind northwest of Wirch has been classified as Valentine fine sandy loam. Northwest of White Stone Battlefield the Williams fine sandy loam approaches the texture and topography of the Williams loam.

Large fields can not be laid out on the Williams fine sandy loam because of the uneven topography, but the farmers of this section utilize a large part of the type. This land was the last in the county

to be occupied. Much of it is 15 miles from any railroad and up to six years ago there were no graded roads into the hills northwest of Forbes. There are a number of springs and small lakes scattered through this region, making it in its native state a desirable grazing country. It supports more stock than most other parts of the county. About a ton of prairie hay per acre is obtained from the hill land, and 2 tons from the depressional areas. The soil is new and produces good yields of flax, oats, wheat, and corn. Yields of 6 or 7 bushels of flaxseed, 20 to 25 bushels of corn, 10 bushels of wheat, and 22 bushels of oats per acre are obtained. This land has an average value of $20 to $25 an acre.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the Williams fine sandy loam:

Mechanical analyses of Williams fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
3514102	Soil	2.0	7.6	5.9	31.3	10.6	34.7	7.7
3514103	Subsoil	.8	1.8	1.4	7.6	12.8	54.9	20.6

The following samples contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 3514102, 0.72 per cent; No. 3514103, 24.45 per cent.

WILLIAMS GRAVELLY LOAM.

The Williams gravelly loam is indicated on the soil map by gravel symbols in Williams fine sandy loam color. The soil is a very dark brown, medium to coarse sandy loam containing considerable fine gravel. The subsoil is encountered at a depth of about 8 inches, and consists of a grayish-brown gravelly loam to a grayish-white, highly calcareous earthy gravel. The soil contains considerable lime carbonate. The topography usually is rolling and morainic. In places it occurs as gravelly knolls surrounded by sags of heavier and deeper soil. Some areas represent outcrops of gravel on the slopes of hills with heavier soils both above and below them. The gravel from which this type is derived is piled in rough, morainic forms, but in places shows some stratification, like large kames. (See Pl. II, fig. 1.)

The smoother areas of this type occur in German Township, while the rougher areas are scattered over the plateau around and south of Wirch. The better areas produce 5 or 6 bushels of wheat per acre, and proportionate yields of other crops, but most of the type is not suited to agriculture, being steep, stony, and droughty. It affords scant pasturage. The average value of this type is $10 to $15 an acre

WILLIAMS LOAM.

The soil of the Williams loam is a dark-brown to very dark brown or occasionally black, mellow loam, 12 inches deep, grading through a few inches of brown, compact loam into a grayish-white or pale yellowish gray, friable loam. The lower subsoil is pale yellow, grayish yellow or light brown, and is usually more compact than the overlying material. The subsoil contains a high percentage of lime carbonate and usually effervesces with acid nearer the surface than the corresponding type of the Barnes series. Some small, angular rock fragments are often present in the soil section. In flat areas the light-gray layer is not encountered at a depth of less than 20 inches, but on slopes and knolls the gray color is often reached near the surface, and may extend to a depth of 3 feet or more.

The Williams loam corresponds in many ways to the Barnes soils, but differs from them in its light-gray and more highly calcareous subsoil, uniformly higher elevation, and somewhat thinner soil layer. Many small spots in the Barnes soils have Williams characteristics, while small areas of soil with Barnes characteristics occur within the Williams areas. The Williams soils are very well drained, so that the gray color is not due to water-logged subsoils, but to a high content of lime and the lack of iron oxide in the subsoil. Cuts in Williams material often do not retain the light-gray color, but oxidize to a pale yellowish brown.

Most of the Williams loam occurs in one large body in the northwestern corner of the county. Another large area occurs south of White Stone Battlefield, while a few small areas are found near and to the south of Wirch. The topography is gently undulating to rolling, and the type is well suited to the use of ordinary farm machinery. Some large depressions and also a few morainic hills occur in this type.

The Williams loam is as good an agricultural soil as the Barnes silt loam, and it is said that crop failures are less frequent on the plateau than on the level prairie. The type is easy to cultivate, is not drifted by the wind, and holds moisture well. Wheat yields about 14 bushels, oats 35 bushels, barley 25 bushels, corn 30 bushels, rye 18 bushels, and potatoes 85 bushels per acre. Yields of 25 to 40 bushels or more of wheat per acre are reported, and other crops do equally well in favorable years.

The average value of this type is $32 to $35 an acre, and well-improved and favorably located land is held for a much higher price.

Results of mechanical analyses of samples of the soil and subsoil of this type are given in the following table:

Mechanical analyses of Williams loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
351426	Soil	1.6	3.7	3.4	16.2	11.4	43.5	15.6
351427	Subsoil	1.5	4.0	2.4	10.0	9.2	49.0	23.7

EDGELEY LOAM.

The Edgeley loam has a surface soil which is dark brown to nearly black in color, loose and mellow in structure, and 8 to 12 inches deep. The subsoil is a light-brown or dull grayish brown, calcareous loam. The type has the same physical characteristics as adjoining areas of Barnes loam, but is distinguished from it by the occurrence of beds of shale rock within 5 feet of the surface and the admixture of considerable quantities of shale fragments with the glacial drift from which the soil is derived.

The Edgeley loam occurs only in a narrow belt which begins near Edgeley, in Lamoure County, and extends southward across Dickey County through range 64, continuing a long distance into South Dakota. This strip varies from about 1 mile to 2 miles in width and is regarded as the poorest land in the county. The presence of shale seems to have a bad effect on the water-holding capacity of the soil. The topography is level or gently undulating, with a few low morainic knobs and ridges breaking the monotony of the plain.

The rougher areas of the Edgeley loam are devoted largely to the production of wild hay and to pasture, while the crops common to the region are grown on the smoother areas. Only fair yields are obtained. The line of separation between the Edgeley and Barnes soils is not distinct, and along the boundary the Barnes, as mapped, is poorer and the Edgeley somewhat better than typical. The type produces from 7 to 10 bushels of wheat, 12 to 15 bushels of barley, about 16 bushels of oats, and 15 to 17 bushels of corn per acre, under present systems of management.

The type is quite variable. As previously noted the depth to the shale makes the land spotted, and fields which look quite uniform in the surface produce crops that are very uneven. Examination of these spots shows considerable variation in the soil. An examination of this type of soil on which good and poor oat crops were growing showed that there was considerable variation in the content of soluble salts or alkali in different spots.[1]

[1] N. D. Agr. Expt. Sta. Special Bulletin (Food Department), vol. 11, No. 4, April, 1912, pp. 55 to 58.

Alkali in Edgeley loam soil growing good and poor oats.

Depth.	Total water-soluble alkali salts.		Sodium carbonate.	
	Good oats.	Poor oats.	Good oats.	Poor oats.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
0 to 9 inches	0.124	0.136	0.055	0.055
9 to 19 inches	.216	1.740	.122	.111
19 to 30 inches	.280	3.910	.160	.120

It will be noted that the soluble-salt content is much higher in the soil growing the poor oats. These soil samples were taken from the same field within 10 feet of each other; this serves to illustrate the variability of the type. The largest amount of alkali is found in the third depth, indicating that the leaching from above and the lack of drainage below have caused an accumulation at this point. There seems to be little variation in the amount of sodium carbonate present, which would indicate that other salts, such as chlorides, sulphates, etc., constitute the greater part of the alkali in the lower depths. A part of the soluble salts may be of such a nature that they are not toxic to plant growth.

The Edgeley loam mapped in the southern part of the county is slightly finer in texture than that in the northern part. The surface soil varies from a loam to a silt loam and the subsurface layer from a loam to a clay loam. The type is quite flat in topography and resembles alluvial deposits somewhat where small watercourses meander through the areas. It is better farming land than that in the northern part of the county. Almost all of it is used for the production of hay and grains.

While small areas contain considerable alkali, and certain areas of the type are no doubt lowered in crop-producing capacity by the presence of alkali, there is not enough seriously to injure the soil type as a whole, if a good system of tillage, crop rotation, and manuring were followed.

While fair crops of small grain can be produced on this type in favorable years, forage crops can be used to good advantage in the cropping system. Cultivated crops will need to be grown frequently in the rotation.

A comparison of the forage produced by corn, brome grass, alfalfa, and clover on this type of soil at the Edgeley substation is shown in the following table:

Yields of forage crops at the Edgeley substation.[a]

Crop.	Number of plots.	Pounds per acre.								
		1907	1908	1909	1910	1911	1912	1913	1914	Average.
Corn	22	2,240	2,010	5,040	1,610	4,630	6,350	4,260	4,050	3,800
Brome grass	4	2,300	2,320	4,280	1,130	1,270	3,950	2,580	3,542	2,670
Alfalfa	2	.....	.....	1,000	1,000	980	3,780	1,650	3,305	1,950
Clover	1	.....	550	00	850	00	00	500	2,480	625

[a] Bul. 110, N. D. Agr. Expt. Sta., p. 179.

Corn leads in the amount of forage produced and brome grass has yielded more than alfalfa or medium red clover. The shale subsoil seems to interfere with the growth of the large root system that develops when alfalfa produces its best crop. Even though alfalfa has not yielded as much forage as corn and brome grass it has averaged a ton of hay per acre, which is a fair yield when it is remembered that alfalfa has a higher feeding value than any of the other forage crops grown in this trial. Medium-red clover has been practically a failure. Other experiments at the Edgeley substation have shown that sweet clover makes a good growth and yields well. The average yield of millet of different varieties has ranged from 1.87 tons to 2.94 tons, Early Fortune giving the smallest yield and Hungarian the largest.

The yields are an average for the five years 1903, 1904, 1905, 1908, and 1912. The rainfall during the growing period in these years was good and these yields are probably above the average for this soil type. In 1910 millet was a complete failure on this type. From these results and the experience of farmers it would seem that broomcorn millet grown for seed should prove to be a profitable crop on this type if it can be marketed to good advantage.

Sweet clover has been grown successfully at the Edgeley substation for several years, and seems to be one of the most promising legume crops for this soil type. It produces a good yield of forage, is a good pasture crop, and one of the best green-manure crops. A good stand can usually be obtained with a nurse crop, and being a biennial it fits into crop rotations without loss of time.

While alfalfa does not yield as well on this soil type as on some of the other types of the county it can be grown profitably. It will yield a good crop of hay and conditions are favorable for seed production in this region in most years. Good yields of seed and forage have been produced at the Edgeley substation. When it is grown primarily for seed the experiments at this station indicate that the best results will be obtained if it is seeded in rows and cultivated.

Where the farm is located sufficiently close to a shipping point potatoes should prove to be a profitable crop on this soil type. At the Edgeley substation the average yield of 21 varieties grown in 132 trials during the period of 1905 to 1912 was 98.9 bushels. The highest yield of any variety during the seven years the trials were carried on was 127.87 bushels per acre, and the lowest yield of any variety for this period was 79.76 bushels per acre.[1] These figures show that with good cultivation and a good variety the potato crop is profitable on this soil type if they can be marketed without too great an expense.

Rotations that would be suitable for this soil type are as follows: (1) Corn, wheat, oats, and sweet clover; (2) potatoes, wheat, barley, and sweet clover; (3) corn, wheat, wheat, and alfalfa, 3 years; (4) corn, wheat, oats, and brome grass 3 years; and (5) corn, wheat, barley, and alfalfa 3 years.

The rotations might need to be modified to suit the conditions on individual farms, but in general they should produce fairly good yields. In the rotations where brome grass or alfalfa is grown on one field for 3 or 4 years a crop of flax might prove to be a profitable crop to seed on the sod the first year it is broken. In case this is done it should not be grown oftener than once in six or eight years on the same field.

The average value of this land is $18 to $20 an acre.

VALENTINE FINE SAND.

The Valentine fine sand is a brown to very dark brown, or, in places, black, loose, incoherent fine sand, about 20 inches deep, underlain by lighter brown to clean and colorless fine sand, which probably continues to great depths without change. In areas of this type the wind has blown the sand into a choppy or billowy topography, with mounds rising 2 to 6 feet above the hollows. A part of this modification by wind has taken place since the sod was first plowed in the early eighties, and wind storms still carry considerable sand. Gullies 2 or 3 feet deep have been eroded in plowed fields, and cuts in sand dunes show an old sod covered with several feet of sand.

This type is mostly confined to the southeastern corner of the county and to an area north of Glover.

Very little of the Valentine fine sand is cultivated. Fields that were once cultivated have largely been abandoned to weeds and grasses. Unbroken areas of the type support a short growth of grass, and the type is best suited for pasture land or for hay production. Alfalfa probably is the best crop for this soil, where a good stand can be obtained.

[1] N. D. Agr. Expt. Sta., Tenth Annual Report of the Edgeley Substation, 1912, p. 33.

The crop-producing capacity of this type is low and much care must be taken to prevent drifting. A fair crop of corn could be produced in some years. If the crop can be removed early and winter rye seeded and top-dressed with an application of fresh manure, drifting could be checked. After the rye crop has been removed the land could be given a light disking, but not enough to cover the stubble. If left in this condition until the following spring, oats could be seeded as a nurse crop for sweet clover. The year following the oats, the land would be in sweet clover. The sweet clover could be followed by corn or potatoes, the land being spring plowed. In this way the land will be afforded protection during the winter and only one plowing in 4 years will be required. This would make the rotation: Corn and potatoes 1 year, winter rye 1 year, oats 1 year, and sweet clover 1 year.

Durum wheat or broom-corn millet might be substituted for the oats, but if the millet is used it should be seeded lightly or it may choke out the sweet clover. Organic matter decays rapidly in sandy, loose-structured soil like this, and farm manure will need to be applied quite frequently. This should be applied where it will help to keep the soil from drifting, but it should eventually be mixed with the entire plowed layer. It should not be plowed under for small grain. In a rotation like the one outlined above a part of it could be plowed under for corn and a part used as top-dressing for the rye.

A variation of this type occurs in the Lake Dakota region, the largest areas being in secs. 11, 12, and 13 in T. 129, R. 59, bordering the county line. The soil of this variation is a brown to grayish-brown, loose, incoherent fine sand, 20 inches deep, underlain by lighter grayish brown to clean and colorless fine sand, which continues to considerable depths without change. It occurs where the wind has modified the sandy lake-bed material, so that it now has a choppy or billowy topography with mounds rising 2 to 6 feet about the hollows. Part of this modification by wind has taken place since the sod was plowed up in the early eighties, and even now the air is often filled with sand during a windstorm. Holes or "blow-outs," 2 or 3 feet deep, have been eroded in plowed fields, and cuts in sand dunes show an old sod covered with several feet of fresh sand. Very little of this variation is now cultivated. Fields that have been broken are largely abandoned to weeds and grasses. Unbroken areas of this variation are covered with a short growth of grass, and the soil should undoubtedly be devoted to pasture or hay. Alfalfa would probably be the best crop for this soil. A stand could be obtained on some of the areas if it were seeded a little late and the ground covered temporarily with a light covering

of manure or straw to check drifting while the young plants are getting a start. When a stand is obtained the field should be maintained as long as possible. After the alfalfa has once established itself it will keep the soil from drifting, but precautions should be taken to prevent soil drifting onto it from other fields.

This land is valued at $10 to $15 an acre.

VALENTINE FINE SANDY LOAM.

The Valentine fine sandy loam is a dark-brown, loose, friable fine sandy loam, 14 to 20 inches deep, underlain by light-brown or yellowish-brown, loose, porous fine sandy loam. The subsoil grades into a heavier and more compact loam at a depth of 30 inches to 5 feet. This soil is of quite uniform texture and usually is stone free. Large areas of the type in range 63 are derived largely from a sandy glacial drift which has been modified somewhat by both water and wind. Other areas, such as those 2 or 3 miles southeast of Fullerton, are plainly derived from sands which have been carried by strong northwest winds from sandy river bottoms or beaches and spread over the till plain. The topography usually is level or gently undulating, but is rough and slightly stony along the low Antelope moraine to the north of Monango. One large area of the type is mapped on the Missouri Plateau several miles northwest of Wirch, where the sandy deposits are quite deep and the subsoil is not light enough in color to warrant classing the material as Williams fine sandy loam. Very few areas of this type occur more than 5 miles east of the Maple River.

The Valentine fine sandy loam is less productive than soils of the Barnes series, since its sandy texture makes it less capable of withstanding drought. Its low value is due also in part to the destructive action of the wind. Like all the sandy soils, this type is infested with Russian thistle and other weeds wherever the land is not covered by a thick stand of crops. Corn, potatoes, alfalfa, and sweet clover can be grown successfully on this type, and rotations containing these crops would help to keep the land clean of weeds, and if the forage were fed and the manure returned to the soil it would increase in productivity. Special precautions should be taken to prevent the drifting of soil of the corn and potato land during the winter and land on which alfalfa has recently been seeded. A light application of manure will help to check drifting under these conditions. Stubble land would probably be less apt to drift if plowed in the spring shortly before seeding. Results at the Edgeley substation seem to indicate that if stubble land is free from weeds fairly good yields can be obtained without plowing loose soils. Plowing tends to loosen soils, and as these soils are already too loose a cropping system shuld be devised

which will reduce to a minimum the number of times the land is plowed. The cultivation given corn and potatoes prepares the best kind of seed bed for small grain, thus eliminating one plowing. If sweet clover is seeded with this small grain the third crop can be grown with one plowing. By the time the sweet clover field is ready to plow, the following spring, the soil will be quite compact and will contain more organic matter than at the beginning, especially if the land was manured during the winter it was in corn stubble. Oats and durum wheat are probably the best small grains to grow on this type. Winter rye might fit into some rotations to good advantage.

A considerable proportion of a farm on this type should be in forage crops. Where a good stand of alfalfa has been obtained it can be left several years. Land growing alfalfa is accumulating organic matter, and if the hay is fed and the manure is returned considerable nitrogen is added. As the organic matter helps to hold the soil together it keeps it from drifting, and as nitrogen is the element of plant food that is exhausted most rapidly on this soil type, this increase in fertility is an important asset in the growing of alfalfa.

The growing of sweet clover and hog millet for seed might prove profitable, if one is familiar with the handling and marketing of these crops.

This type has an average value of about $25 an acre.

ROUGH BROKEN LAND.

Rough broken land includes nonagricultural land or at least land that is too rough to be farmed by the extensive methods practiced in North Dakota. Some areas are more rocky than broken. It occurs as long strips from one-eighth to one-half mile wide along the James River Valley where the hills are rather steep and gullied and include rocky knolls. A few small areas are mapped on morainic hills east of Oakes, but the largest bodies are encountered on the slope of the Missouri Plateau in the western part of the county. A rise of nearly 300 feet takes place within a distance of 1 to 3 miles, the topography being broken and hilly. A number of draws or "gulches" have been cut in this slope, but erosion is not now active, as all but the steepest bluffs are covered with thick sod. (See Pl. II, fig. 2.) On the plateau there are some morainic hill areas that are sometimes rough, rocky, and gravelly enough to be unfit for farming. However, the farmers of this region utilize many small patches of land for agriculture. Hay is cut from many small, irregularly shaped fields in the Rough broken land areas, but most of such land is used for pasture.

Where good springs or lakes are present this land sometimes sells for as much as $20 an acre, but without these it is valued at less than $10 an acre for pasture.

CHEMICAL COMPOSITION OF SOILS.

In the following table are given the results of complete analyses of several of the more important soils of Dickey County. The composition of the soils is expressed in pounds per acre. The samples have been taken in three depths—0 to 7 inches, representing the surface soil; 7 to 18 inches, representing the subsurface layer; and 18 to 40 inches, representing the subsoil. The weight of the surface soil has been estimated at 2,000,000 pounds, the subsurface layer at 4,000,000 pounds, and the subsoil at 6,000,000 pounds. In taking samples for analyses representative areas of each soil were selected and several borings taken to make a composite sample. Several such samples were taken of the more important types.

Chemical analyses of the more important soils of Dickey County.

UPLAND SOILS—GLACIAL AND LOESSIAL PROVINCE.

[Pounds per acre.]

Soil types.	Surface, 0 to 7 inches.			Subsurface, 7 to 18 inches.			Subsoil, 18 to 40 inches.		
	Total nitrogen.	Total phosphorus.	Limestone present.	Total nitrogen.	Total phosphorus.	Limestone present.	Total nitrogen.	Total phosphorus.	Lime stone present.
Barnes silt loam	6,580	1,234	713	6,640	1,852	20,893	4,314	2,862	606,909
Barnes silty clay loam	7,710	1,329	333	9,080	2,034	2,592	4,527	2,214	362,973
Barnes very fine sandy loam	6,240	1,076	699	5,560	1,328	327	4,140	2,628	581,574
Williams loam	7,460	1,278	352	7,000	1,856	54,480	5,280	2,616	546,162
Williams fine sandy loam	5,100	1,014	2,410	4,400	1,516	97,156	3,960	2,148	224,730
Edgeley loam	4,550	918	338	4,240	1,346	23,803	3,744	1,941	614,112
Valentine fine sandy loam	3,240	854	4,680	3,200	1,724	290,560	2,140	2,622	770,892
TERRACE AND LAKE-BOTTOM SOILS—GLACIAL LAKE AND RIVER TERRACE PROVINCE.									
Bearden fine sand	4,070	1,005	435	4,900	1,732	70,189	3,898	2,586	346,751
Bearden fine sandy loam	4,100	980	13,620	2,024	1,488	760,904	1,920	2,130	1,114,116
Bearden very fine sandy loam	6,040	1,082	735	7,040	1,944	1,471	3,900	2,574	882,576
BOTTOM-LAND SOILS—RIVER FLOOD PLAINS PROVINCE.									
Lamoure clay	7,440	1,330	18,692	7,560	2,252	177,060	7,620	3,654	559,782
Lamoure silty clay	7,020	1,884	16,117	11,520	2,976	129,832	9,480	4,044	505,302

SUMMARY.

Dickey County lies along the southern boundary of North Dakota, about 70 miles west of Minnesota. It has an area of 1,142 square miles, or 730,880 acres. The county comprises three main physiographic divisions: (1) An old, sandy lake bed; (2) level, treeless prairie; and (3) a high, rolling plain—the Missouri Plateau. The lower plain, including the lake bed and the prairie, ranges in elevation from 1,300 to 1,700 feet above sea level, and the elevation of the plateau averages about 2,000 feet above sea level. On the plateau and in the Lake Dakota basin regional drainage has not been established. The remainder of the county is imperfectly drained by streams which empty into the James River.

The total population of Dickey County in 1910 was 9,839, all of which is classed as rural. The two principal towns are Ellendale, the county seat, with a population of about 1,400, and Oakes, with a population of about 1,500. The county is well supplied with transportation facilities.

The climate is characterized by long, cold winters and short, cool summers. The mean annual temperature is reported as 40° F. and the mean annual precipitation as about 23 inches. The growing season averages 122 days.

Agricultural development commenced in Dickey County about 1880. After 12 or 14 years of pioneer farming, which in many cases proved unprofitable, a definite system became established, based on the production of wheat as the money crop, with oats and corn as feed for stock.

Grain farming is now the predominant type of agriculture. Cereals, chiefly wheat, flaxseed, and hay and forage make up nearly 90 per cent of the value of all farm products, while only about 7 per cent of the total value is represented by live-stock products. Vegetables, fruit, and poultry and dairy products are of minor importance.

Of the total area of the county 81.4 per cent is reported in farms in the 1910 census, and of the farm land 69.6 per cent is reported improved. The average size of the farms is given as 546 acres. The average acreage value of farm land is given as $33.45. About 73 per cent of the farms are operated by the owners. The adoption of scientific methods of farming is progressing rapidly.

The soils of this county are derived from glacial drift, either weathered in the position in which it was left by the ice or transported and redeposited as glacial stream terraces, as recent alluvium or as æolian deposits. The drift consists of materials derived from granite, limestone, shale, and sandstone of many formations, and varies from a thin veneer to beds 80 or 90 feet in thickness.

The soils are classed in 10 series, including 28 types, and the miscellaneous type Rough broken land.

The soils of the glacial drift region, covering the greater part of the county, are classed with the Barnes, Williams, and Edgeley series. The glacial-lake and river-terrace soils are the Sioux, Fargo, Rogers, Maple, Bearden, and Valentine series, the last being composed of wind-blown material. The first-bottom soils are classed with the Lamoure series.

The Barnes series predominates east of the Missouri Plateau, and comprises much of the best farming land in the county. The Williams series is the glacial soil of the Missouri Plateau and is characterized by a light-gray subsoil. The Edgeley series, represented by the loam type, forms poor agricultural land, the soil being mixed with shale fragments and underlain by shale rock at shallow depths.

The Sioux series includes river-terrace soils underlain by gravel beds, and when these lie at shallow depths the water-holding capacity of the soil is somewhat deficient. The Fargo, Rogers, and Maple series are lake-bed soils of little present value except for the production of hay. The Rogers soils are strongly impregnated with alkali and the Maple to some extent. The Valentine series is made up of sandy wind-blown material. The Bearden series includes good, nondroughty terrace soils.

The Lamoure soils occur in the first bottoms of streams. These are deep, strong soils, not subject to drought.

Rough broken land comprises areas which are too rough and rocky for agricultural use.

[PUBLIC RESOLUTION—No. 9.]

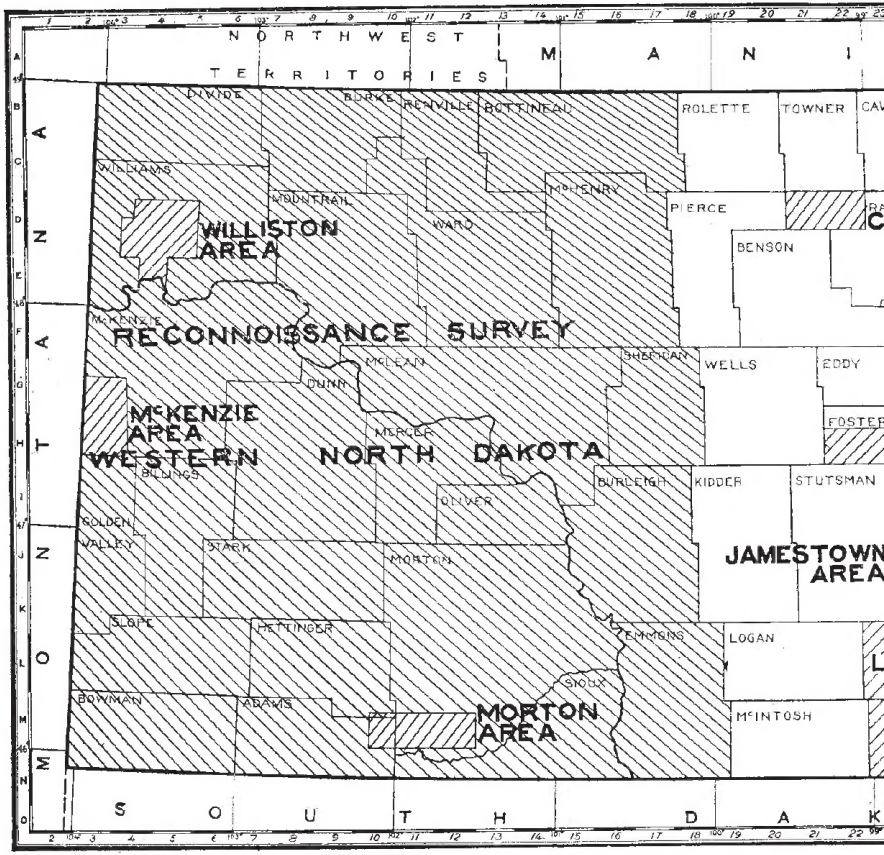
JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, be amended by striking out all after the resolving clause and inserting in lieu thereof the following:

That there shall be printed ten thousand five hundred copies of the report on field operations of the Division of Soils, Department of Agriculture, of which one thousand five hundred copies shall be for the use of the Senate, three thousand copies for the use of the House of Representatives, and six thousand copies for the use of the Department of Agriculture: *Provided,* That in addition to the number of copies above provided for there shall be printed, as soon as the manuscript can be prepared, with the necessary maps and illustrations to accompany it, a report on each area surveyed, in the form of advance sheets, bound in paper covers, of which five hundred copies shall be for the use of each Senator from the State, two thousand copies for the use of each Representative for the congressional district or districts in which the survey is made, and one thousand copies for the use of the Department of Agriculture.

Approved, March 14, 1904.

[On July 1, 1901, the Division of Soils was reorganized as the Bureau of Soils.]



Areas surveyed in North Dakota.

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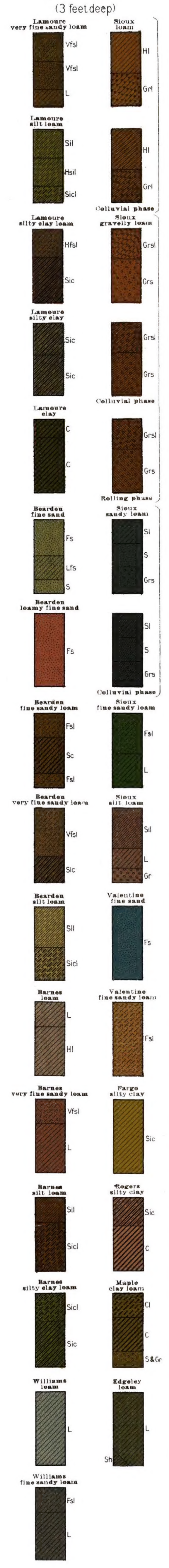
U. S. DEPT. OF AGRICULTURE
BUREAU OF SOILS
MILTON WHITNEY, CHIEF
CURTIS F. MARBUT, IN CHARGE SOIL SURVEY

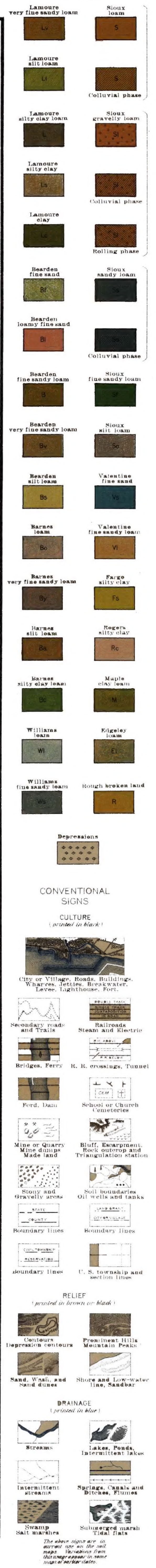
SOIL MAP
NORTH DAKOTA
DICKEY COUNTY SHEET

NORTH DAKOTA AGRICULTURAL EXPERIMENT STATION
THOMAS P. COOPER, DIRECTOR.

SOIL PROFILE
(3 feet deep)



LEGEND



Curtis F. Marbut, Inspector in Charge.
Soils surveyed by T. M. Bushnell, in charge,
E. H. Smies, and W. I. Watkins of the U. S. Department
of Agriculture, and A. C. Anderson, Melvin Thomas,
Murray E. Stebbins, R. C. Doneghue, and J. W. Ince, of the
North Dakota Agricultural Experiment Station.

Scale 1 inch = 1 mile

Field Operations
Bureau of Soils
1914